PB-231 064

EFFECTIVENESS OF SHORT EMISSION INSPECTION TESTS IN REDUCING EMISSIONS THROUGH MAINTENANCE

R. D. Gafford, et al

Olson Laboratories, Incorporated

Prepared for:

Environmental Protection Agency

July 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

BIBLIOGRAPHIC DATA SHEET

1. Report No. EPA-460/3-73-009

2.

PB 231 064

4. Title and Subtitle

Effectiveness of Short Emission Inspection Tests in Reducing Emissions Through Maintenance

5. Report Date July 1973

6.

7. Author(s) R. D. Gafford and T. A. Huls

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Olson Laboratories, Inc.
421 E. Cerritos Avenue
Anaheim, California 92805

10. Project/Task/Work Unit No.

11. Contract/Grant No. 68-01-0410

12. Sponsoring Organization Name and Address

U. S. ENVIRONMENTAL PROTECTION AGENCY - OAWP
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48015

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

This report documents the conduct, methodology, and results obtained from a two-phase study. The objective of an inspection regime would be to detect those malfunctions which are most likely to result in mass emissions to the atmosphere. The effectiveness measure selected for this study was the amount of emission reduction measured by the 1975 CVS Federal Test Procedure. The "short cycle" project was initiated to evaluate two methods (loaded and unloaded) of inspection and resulting maintenance. The primary objective was to determine emission reductions, costs, cost effectiveness of the Idle (unloaded) and dynamometer Loaded Steady State (L.S.S.) inspection and maintenance regimes. A secondary objective was to determine how well various short emission inspection test, including Idle and L.S.S., correlated with the 1972 and 1975 CVS Federal Test Procedures. It describes the organization of the study, vehicle procurement, testing procedures, data reduction and analytical techniques. The conclusions are presented for each of the objectives cited. Test procedures and vehicle emission summary tables are appended to the report.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Maintenance
Exhaust emissions
Cost effectiveness
Inspection
Cost analysis
Hydrocarbons
Carbon monoxide
Nitrogen oxides
Motor vehicle engine
Performance
Standards
Carburetors

17b. Identifiers/Open-Ended Terms

Idle emission test
Loaded steady state emission test
1975 CVS Federal Test
1972 CVS Federal Test

17c. COSATI Field/Group 13B 13F

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

18. Availability Statement

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 303

22. Price 18.25/1.45

i.

EPA-460/3-73-009

EFFECTIVENESS OF SHORT EMISSION INSPECTION TESTS IN REDUCING EMISSIONS THROUGH MAINTENANCE

Prepared by

R. D. Gafford and T. A. Huls

Olson Laboratories, Inc.
421 E. Cerritos Avenue
Anaheim, California 92805

Contract No. 68-01-0410

EPA Project Officer:

Thomas A. Huls

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

July 1973

ia

This report is issued by the Environmental Protection Agency to report technical data of interest to a limited number of readers. Copies are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Air Pollution Technical Information Center, Environmental Protection Agency, Research Triangle Park, North Carolina 27711, or from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

This report was furnished to the Environmental Protection Agency by Olson Laboratories, Inc., Anaheim, California in fulfillment of Contract Number 68-01-0410. The contents of this report are reproduced herein as received from the Olson Laboratories, Inc. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency. Mention of company or product names is not to be considered as an endorsement by the Environmental Protection Agency.

Publication No. EPA-460/3-73-009

TABLE OF CONTENTS

SECTION PAGE

1.0 INTRODUCTION AND SUMMARY 1-001

1.1 Introduction 1-001
1.1.1 Inspection and Maintenance Programs 1-001
1.1.2 Program Objectives 1-002
1.2 Experimental Design 1-003
1.3 Data Analysis 1-004
1.4 Results of the Effectiveness Analysis 1-005
1.4.1 Test Fleet Emission Reductions 1-005
1.4.2 Effectiveness Index 1-008
1.4.3 Emission Reductions as a Function of Failure Rate 1-009
1.4.4 Effectiveness of Repairing Idle Only Failures . . . 1-011
1.5 Results of Maintenance Analysis 1-011
1.5.1 Modal Failures 1-012
1.5.2 Diagnosis of Failed Vehicles 1-012
1.5.3 Repair Action Summary 1-015
1.5.4 Excess Repairs 1-015
1.6 Results of Cost Analysis 1-016
1.6.1 Inspection Program Costs 1-016
1.6.2 Vehicle Maintenance Cost 1-016
1.6.3 Total Program Cost 1-018
1.7 Results of the Cost Effectiveness Analysis 1-021
1.7.1 Fleet Cost Effectiveness 1-021
1.7.2 Cost Effectiveness Index 1-022
1.8 Results of the Relatability Analysis 1-022
1.8.1 Short Test Correlation to 1975 CVS 1-024
1.8.2 Errors of Commission 1-024
1.9 Summary Conclusions 1-025
1.9.1 Effectiveness Analysis 1-025
1.9.2 Maintenance Analysis 1-026
1.9.3 Cost Analysis 1-026
1.9.4 Cost Effectiveness Analysis 1-027
1.9.5 Relatability Analysis 1-027

2.0 TEST PROGRAM METHODOLOGY 2-001

2.1 Study Team 2-001
2.2 Inspection and Maintenance Operations 2-001
2.2.1 Vehicle Procurement 2-004
2.2.2 Emission Testing 2-005
2.2.3 Vehicle Maintenance 2-010
2.2.3.1 Vehicle Service Centers 2-012
2.2.3.2 Idle Service Procedure 2-012
2.2.3.3 Loaded Steady State (L.S.S.) Service Procedure 2-012

TABLE OF CONTENTS

SECTION PAGE

2.3 Data Analysis 2-013
2.3.1 Data Acquisition 2-013
2.3.2 Fleet Emission Statistics 2-013
2.3.3 Effectiveness Analysis 2-017
2.3.3.1 Fleet Emission Reductions 2-017
2.3.3.2 Emission Reductions as a Function of Inspection Test Rejection Rate 2-019
2.3.3.3 Effectiveness of Correcting Idle Only Failures 2-020
2.3.3.4 Effectiveness Index 2-020
2.3.4 Maintenance Analysis 2-024
2.3.4.1 Modal Failure Analysis 2-024
2.3.4.2 Diagnosis of Failed Vehicles 2-024
2.3.4.3 Service Center Repair Action 2-025
2.3.4.4 Unjustified Repair Action 2-027
2.3.4.5 Analysis of Exited Failing Vehicles 2-028
2.3.5 Program Cost Analysis 2-028
2.3.5.1 Inspection Cost Analysis 2-029
2.3.5.2 Maintenance Cost Analysis 2-030
2.3.5.3 Total Program Cost 2-031
2.3.6 Cost Effectiveness of Inspection and Maintenance 2-032
2.3.7 Relatability Analysis 2-032
2.3.7.1 Correlation and Regression Analysis 2-032
2.3.7.2 Errors of Commission Analysis 2-034

3.0 PROGRAM RESULTS 3-001

3.1 Test Fleet Statistics 3-001
3.1.1 Test Fleet Vehicle Composition 3-002
3.1.2 Dependence of Emissions on Vehicle Parameters . . . 3-002
3.1.3 Test Fleet Emission Levels 3-006
3.1.4 Statistical Equivalence of Test Fleets Before Maintenance 3-012
3.1.4.1 Equivalence of Idle and L.S.S. Fleets 3-012
3.1.4.2 Equivalence of California and Michigan 3-016
3.1.4.3 Equivalence of Phase I and Phase II 3-016
3.2 Effectiveness Analysis 3-018
3.2.1 Test Fleet Emission Reductions 3-018
3.2.2 Test of Significance of Emission Reduction 3-023
3.2.2.1 Significant Difference in Idle and L.S.S. Emission Reductions 3-023
3.2.2.2 Significant Differences in Emission Reductions in California and Michigan 3-025

TABLE OF CONTENTS

SECTION PAGE

3.2.2.3 Significant Differences in Emission Reductions Between Phase I and Phase II 3-025
3.2.3 Emission Reductions as a Function of Inspection Test Rejection Rate 3-025
3.2.4 Effectiveness of Correcting Idle Only Failures 3-029
3.2.5 Effectiveness Index 3-032
3.3 Inspection and Maintenance Analysis 3-036
3.3.1 Inspection Test Modal Failures 3-036
3.3.2 Diagnosis of Failed Vehicles 3-039
3.3.3 Repair Action Summary 3-042
3.3.4 Unjustified Repair Action Analysis 3-047
3.3.5 Failed and Exited Vehicles 3-050
3.3.6 Revised Maintenance Procedure Recommendations . . 3-053
3.3.6.1 Suggested Procedure 3-053
3.3.6.2 Implementation Philosophy 3-054
3.4 Cost Analysis 3-054
3.4.1 Inspection Program Costs 3-057
3.4.2 Maintenance Cost Analysis 3-059
3.4.2.1 Average Serviced Vehicle Costs 3-059
3.4.2.2 Excess Repair Costs 3-060
3.4.2.3 Repair Cost as a Function of Inspection Test Rejection Rate 3-064
3.4.2.4 Average Repair Cost for Service Actions 3-069
3.4.2.5 Average Repair Cost for Correcting Idle Only Failures 3-071
3.4.3 Total Program Costs 3-071
3.5 Cost Effectiveness Analysis 3-074
3.5.1 Cost Effective Index 3-074
3.5.2 Cost Effectiveness as a Function of Inspection Test Rejection Rate 3-076
3.5.3 Cost Effectiveness of Correcting Idle Only Failures 3-076
3.6 Relatibility Analysis 3-079
3.6.1 Correlation and Regression Results 3-079
3.6.2 Errors of Commission 3-099

REFERENCES 3-102

4.0 APPENDICES 4-001

4.1 Appendix A - Test Procedures 4-001
4.2 Appendix B - Vehicle Emission Summary Tables . . . 4-001
4.3 Appendix C - Short Test Regression and Correlation Summaries 4-001

LIST OF TABLES

TABLE		PAGE
1-01	Summary Statistics for All Vehicles	1-006
1-02	Summary Statistics for Serviced Vehicles Only	1-007
1-03	Tests of Significance of Emission Reduction	1-009
1-04	First Year Effectiveness Index	1-009
1-05	Emission Reductions from Correcting Idle Only Failures	1-011
1-06	Modal Failures of L.S.S. Vehicles	1-012
1-07	Inspection Program Costs	1-016
1-08	Average Service Cost	1-017
1-09	Average Cost for Service Event	1-017
1-10	Average Repair Cost of Correcting Idle Only Failures	1-018
1-11	First Year Total Program Cost - Combined States	1-018
1-12	Annual Vehicle Owner Cost - Combined States	1-021
1-13	Cost Effectiveness of Correcting Idle Only Failures	1-022
1-14	First Year Program Cost Effectiveness - Combined States	1-024
2-01	Vehicle Distribution by Model Year	2-005
2-02	California Vehicle Population	2-006
2-03	Michigan Vehicle Population	2-007
2-04	Horsepower Values for Loaded Steady State Test	2-009
2-05	Emission Inspection Failure Limits	2-011
2-06	Reject Levels for Loaded Steady State Test	2-014
2-07	Average Miles Driven Annually	2-022
2-08	Calculation of Pollutant Weighting Factors	2-023
2-09	Suggested Repair Action for Idle and Loaded Steady State Inspection Test	2-025
2-10	Proper Repair Action, Idle Mode	2-028
2-11	Proper Repair Action, Loaded Steady State	2-028
3-01	Inspection Test Failure Rates	3-004
3-02	General Trends in Mass Emissions	3-005
3-03	Emission Levels for All Vehicles	3-008
3-04	Emission Levels for Serviced Vehicles Only	3-009
3-05	Emission Levels for Controlled Vehicles Only	3-010
3-06	Emission Levels for Uncontrolled Vehicles Only	3-011
3-07	Emission Reductions for All Vehicles	3-019
3-08	Emission Reductions for Serviced Vehicles Only	3-020
3-09	Emission Reductions for Controlled Vehicles Only	3-021
3-10	Emission Reductions for Uncontrolled Vehicles Only	3-022
3-11	Tests of Significance of Emission Reductions After First Service	3-024
3-12	Test of Significance of Emission Reductions After Second Service	3-026

LIST OF TABLES

TABLE PAGE

3-13 Fleet Emission Reduction from Correcting Idle Only Failures 3-030
3-14 Serviced Vehicle Emission Reduction from Correcting Idle Only Failures 3-030
3-15 Relative Effectiveness of Correcting Idle Only Failures 3-031
3-16 Effectiveness Index Input Data (Grams Per Mile Reduction) 3-033
3-17 Effectiveness Index Input Data (Percent Reductions) 3-034
3-18 First Year Effectiveness Index - 1975 CVS Data 3-035
3-19 Distribution of Inspection Test Modal Failures 3-037
3-20 Diagnosis of Repaired Vehicles 3-040
3-21 Repair Action Summary 3-043
3-22 Service Event Summary 3-046
3-23 Summary of Unjustified Repair 3-049
3-24 Summary of Failed and Exited Vehicles 3-051
3-25 Suggested Diagnosis and Maintenance Procedure 3-055
3-26 Inspection Program Costs, State or Single Contractor Operated 3-058
3-27 Service Cost Averaged Over Serviced Vehicles Only 3-060
3-28 Service Cost Averaged Over All Vehicles 3-061
3-29 Percent of Repair Cost Which Was Excessive 3-061
3-30 Average Cost for Service Event 3-070
3-31 Average Repair Cost of Correcting Idly Only Failures 3-072
3-32 First Year Total Program Cost 3-073
3-33 First Year Program Cost Effectiveness 3-075
3-34 Fleet Cost Effectiveness of Correcting Idle Only Failures 3-079
3-35 Ranking of Short Inspection Test Correlation to 1975 CVS Test, 300 California Vehicles 3-081
3-36 Ranking of Short Inspection Test Correlation to 1975 CVS Test, 300 Michigan Vehicles 3-082
3-37 Ranking of Short Inspection Test Correlation to 1975 CVS Test, Combined States 3-083
3-38 Selected Regression Equations and Coefficients, 1975 CVS Before Service Data, California Vehicles Only 3-088
3-39 Selected Regression Equations and Coefficients, 1975 CVS Before Service Data, Michigan Vehicles Only 3-089
3-40 Selected Regression Equations and Coefficients, 1975 Before Service Data, Combined States 3-090
3-41 Analysis of Errors of Commission 3-100

4-01 Short Test Abbreviations 4-002

LIST OF FIGURES

FIGURE PAGE

1-01 Effectiveness as a Function of Rejection Rate 1-010
1-02 Comparison of Repairs Required and Repairs Performed to Pass the Emission Inspection Tests - Phase I 1-013
1-03 Comparison of Repairs Required and Repairs Performed to Pass the Emission Inspection Tests - Phase II 1-014
1-04 Average Vehicle Repair Costs - Phase I 1-019
1-05 Average Vehicle Repair Costs - Phase II 1-020
1-06 Cost Effectiveness as a Function of Failure Rate 1-023

2-01 Short Cycle Project Organization 2-002
2-02 Short Cycle Project Vehicle Flow 2-003
2-03 Data Analysis Flow Chart 2-015
2-04 Service Center Repair Analysis 2-026
2-05 Confidence Bands of Predicted CVS Emission Levels 2-035
2-06 Errors of Commission Analysis 2-036

3-01 Distribution of Test Fleets - Phase I (30% Rejection Rate) 3-003
3-02 Distribution of Test Fleets - Phase II (30% Rejection Rate) 3-003
3-03 95% Confidence Intervals of HC Before and After Service Fleet Means 3-013
3-04 95% Confidence Intervals of CO Before and After Service Fleet Means 3-014
3-05 95% Confidence Intervals of NO_x Before and After Service Fleet Means 3-015
3-06 Effectiveness as a Function of Rejection Rate - California 3-027
3-07 Effectiveness as a Function of Rejection Rate - Michigan 3-028
3-08 Inspection Test Modal Failures. All Phase I and II Vehicles 3-038
3-09 Failed Vehicle Diagnosis 3-041
3-10 Repair Action Summary 3-044
3-11 Unjustified Repair Actions 3-048
3-12 Distribution of Average Repair Cost per Repaired Vehicle 3-062
3-13 Distribution of Average Repair Cost per Repaired Vehicle 3-063
3-14 Average Vehicle Repair Costs - Phase I 3-065
3-15 Average Vehicle Repair Costs - Phase II 3-066
3-16 Average Vehicle Repair Costs Less Excess Repairs - Phase I 3-067

LIST OF FIGURES

FIGURE PAGE

3-17 Average Vehicle Repair Costs Less Excess Repairs - Phase II 3-068
3-18 Cost Effectiveness as a Function of Failure Rate - Phase I 3-077
3-19 Cost Effectiveness as a Function of Failure Rate - Phase II 3-078
3-20 Dependence of Correlation on Number of Steady State Speeds - California 3-085
3-21 Dependence of Correlation on Number of Steady State Speeds - Michigan 3-086
3-22 Dependence of Correlation on Number of Steady State Speeds - All Vehicles 3-087
3-23 HC Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test - Phase I and II Uncontrolled Vehicles . . 3-091
3-24 HC Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test - Phase I and II Uncontrolled Vehicles 3-092
3-25 HC Confidence Bands of Predicted 1975 CVS Emission Idle Inspection Test - Phase I and II Controlled Vehicles . . . 3-093
3-26 HC Confidence Bands of Predicted 1975 CVS Emission Loaded Steady State Inspection Test - Phase I and II Controlled Vehicles 3-094
3-27 CO Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test - Phase I and II Uncontrolled Vehicles 3-095
3-28 CO Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test - Phase I and II Uncontrolled Vehicles 3-096
3-29 CO Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test - Phase I and II Controlled Vehicles 3-097
3-30 CO Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test - Phase I and II Controlled Vehicles 3-098

SECTION 1

INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This report documents the conduct, methodology, and results obtained from a two-phase study performed for the Environmental Protection Agency under Contract #68-01-0410, "Effectiveness of Short Emission Inspection Tests in Reducing Emissions through Maintenance." Throughout the report, this study of periodic vehicle inspection and maintenance will be referred to as the "Short Cycle Project."

This report is presented in four sections as follows:

Section 1: Introduction and Summary

Section 1 is a summary of the study purpose, methodology, results, and conclusions. Typical and general results are presented without detailed discussion and support data.

Section 2: Program Methodology

Section 2 provides the detailed discussion of study organization, testing procedures and analytical methodology.

Section 3: Program Results

Section 3 provides detailed discussion of study results, interpretation and conclusions.

Section 4: Appendices

Section 4 contains detailed test and maintenance procedures and detailed tables of data for the 1975 CVS test procedures.

1.1.1 Inspection and Maintenance Programs

Periodic Vehicle Inspection and Maintenance (PVIM) programs are being considered in several states as one means of achieving Federal air quality standards. EPA is required to review and approve the PVIM program proposed by each state. The EPA, therefore, requires information on the emission reductions and associated costs of a mandatory PVIM program.

The purpose of a PVIM program is to identify and correct vehicles with excessive emissions. High emissions of HC and CO are attributable to malfunctioning components of the vehicle and generally can be corrected by appropriate maintenance. The inspection regimes which are best at identifying excess emissions under some operating conditions may not be able to identify excess emissions under all conditions. The objective of an inspection regime would be to detect those malfunctions which are most likely to result in excessive mass emissions to the atmosphere.

The effectiveness measure selected for this study was the amount of emission reduction measured by the 1975 CVS Federal Test procedure. This test measures mass emissions during a typical 7.5 mile drive (23 minutes duration) from a "cold start" and from a "hot start." The "cold start" test is similar to the 1972 CVS procedure. The emission values are subsequently weighted for cold and hot start operation to form a composite emission value to represent mass emissions to the atmosphere.

1.1.2 Program Objectives

The "Short Cycle" project was initiated to evaluate two methods (loaded and unloaded) of inspection and resulting maintenance. The primary objective was to determine emission reductions, cost, and cost effectiveness of the Idle (unloaded) and dynamometer Loaded Steady State (L.S.S.) inspection and maintenance regimes. A secondary objective was to determine how well various short emission inspection tests, including Idle and L.S.S., correlated with the 1972 and 1975 CVS Federal Test Procedures. This is important since the CVS procedures measure the official emissions of the vehicles and are the emission certification tests for new vehicles.

The following are the principal questions which this study seeks to answer:

1. Which inspection and maintenance regime is the most effective in reducing emissions?

2. Which inspection and maintenance regime is the most cost effective in reducing emissions?

3. Which short cycle tests are the most accurate predictors of emissions which would be obtained using the CVS procedures?

4. What confidence can be placed in the predictions of the CVS results based on short cycle test data and what are the confidence intervals of the predictions?

5. What are the typical causes of excess emissions, and are automotive mechanics able to correct them effectively?

6. What are the expected costs of correcting excess emissions?

7. Will a short inspection test fail the same vehicles which would have failed a CVS procedure and pass-fail limits set to fail the same percentages of the population?

1.2 EXPERIMENTAL DESIGN

The study was designed to provide a comparison of emission reductions and associated costs for the Idle and two L.S.S. inspection and maintenance regimes. The study was based on 600 privately owned passenger cars in a two phase test program; each phase consisting of 300 vehicles. One half of the vehicles in each phase (150 vehicles) were tested in Anaheim, California and the other half were tested in Dearborn, Michigan. The two locations provided a comparison of PVIM in two areas with different climatic conditions and public awareness of automotive pollution.

The 150 vehicles in each city were then divided into 75 pairs of vehicles matched according to criteria described in Paragraph 2.2.1. One vehicle of each pair was assigned to the Idle fleet; the other member of the pair was assigned to the L.S.S. fleet. The vehicles were procured following a standard pattern of representative sampling, and provided equivalent Idle and L.S.S. sample test fleets representative of California and Michigan state vehicle populations in vehicle age and make. The same vehicle distribution procurement and testing procedures were used in both Phases.

Phase I of the program provided a comparison of the unloaded Idle emission inspection test plus repair industry diagnosis of mechanical malfunctions and the L.S.S. inspection using loaded idle and two cruise modes plus repair industry diagnosis using the failure modes of HC and CO indicated from the inspection test. Three repair garages were selected for each vehicle fleet, were provided with NDIR HC/CO exhaust gas analyzers and briefly instructed by OLI personnel in emission diagnosis and repair concepts.

Phase II of the program provided a comparison of the unloaded Idle emission inspection test and industry diagnosis with the L.S.S. inspection using loaded idle and two cruise modes. The failure modes were related to probable engine malfunctions using an instruction booklet. In Phase II, the L.S.S. inspection and maintenance procedure was the KEY MODE Emission Evaluation System developed by the Clayton Manufacturing Company (El Monte, California). During Phase II, three different repair garages were used for each vehicle fleet. Each garage was provided an HC/CO exhaust gas analyzer. OLI personnel instructed the Idle garages. OLI and Clayton Manufacturing Co. personnel instructed the L.S.S. garages.

During both phases, rejection limits were set to fail approximately 50% of the vehicle populations. Rejection limits were based on the results of the previous Northrop/ARB study (reference 1). During Phase II, the limits were further adjusted to attain at least 50% rejection in each controlled and uncontrolled vehicle subfleet.* The resulting L.S.S. rejection limits were therefore different than those recommended by Clayton Manufacturing Co. for both Phases.

*Controlled vehicles were equipped with PCV and exhaust emission controls; uncontrolled vehicles were either unequipped or had PCV controls only.

During testing for both phases every vehicle was subjected to a two hour dynamometer test sequence each time it was tested. The driving cycles utilized and the order in which they were performed are listed below:

*1. 1972 Driving Schedule from a "Cold Start," CVS Certification Test (Modified for 4 bag analysis)

*2. 10-minute soak

*3. First 505 seconds of 1972 Driving Schedule, CVS Certification Test (2 bags)

4. EPA 9 Mode CVS Short Cycle (1 bag)

5. Loaded Steady State - KEY MODE inspection test with automatic transmissions in drive at idle. Simultaneous mass and volumetric measurements

6. Steady states - Simultaneous mass and volumetric measurements 60 mph, 50 mph, 40 mph, 30 mph, 20 mph, 10 mph.

7. Idle - Simultaneous mass and volumetric measurements (Automatic transmissions in neutral)

8. Two hot start 7 mode cycles - Simultaneous volumetric and 1 bag CVS mass measurements

Vehicles in the Idle and L.S.S. test fleets were inspected and failed by their respective emission levels. If the vehicle passed its initial inspection test, it was returned to its owner. If the vehicle failed, it was sent to an independent garage for servicing. California garages were state licensed Class A stations; Michigan garages were general service stations and general repair garages. This service resulted in corrective action as described in Section 2.2.3. After servicing, the vehicle was retested again using the entire two hour dynamometer procedure. If the vehicle failed its "after first service" test, the cause of the failure was diagnosed and the vehicle was given additional servicing and retested or rejected without further repair if the diagnosis indicated major mechanical problems such as valve or ring failure.

1.3 DATA ANALYSIS

Five general analyses were applied to the data for each test regime: 1) emission reduction effectiveness, 2) maintenance action, 3) cost, 4) cost effectiveness, and 5) relatability. Detailed discussion of the methodology is presented in Section 2. These analyses discuss Phase I and Phase II separately using rejection limits intended to fail approximately 30% of the vehicles.

The effectiveness analysis considered the emissions reductions of HC, CO, and NO_x by vehicle population for each state, model-year and make distributions, average mileage accumulation, vehicle age and various inspection failure rates.

*These three steps represent the 1975 CVS dynamometer procedure.

The maintenance analysis identified the modes of emission inspection failure, the work which would be expected to correct the excessive emissions, the actual work performed by the garages, an evaluation of excessive work and the reason for failure of those vehicles which were not brought into compliance with the inspection test limits.

The cost analysis included repair cost for the following types of repair: minor adjustment, ignition, carburetion, minor parts, and major mechanical. Cost were determined for repairs judged to be excessive or unjustified. First service and second service costs are presented for controlled and uncontrolled vehicles at various rejection rates.

The cost effectiveness analysis combined the result of the cost and effectiveness analyses. The cost effectiveness for controlled and uncontrolled vehicles is presented as a function of failure rate. The overall fleet cost effectiveness for Phase I and Phase II is also presented.

The relatability analysis provided correlation coefficients and equations for the various short inspection tests and the 1972 and 1975 CVS test procedures. Confidence intervals of the regressions were determined. The number of commission errors of Idle and L.S.S. relative to 1972 and 1975 CVS data was determined for several rejection rates. The relatability analysis was performed for combined Phase I and Phase II data.

1.4 RESULTS OF THE EFFECTIVENESS ANALYSIS

This section presents the effectiveness analysis based on emission reductions including second service. The statistical significance of the emission reductions are also discussed.

1.4.1 Test Fleet Emission Reductions

Idle and L.S.S. fleet emission averages before and after service are shown in Table 1-1 for all vehicles and in Table 1-2 for the serviced vehicles only. Data for Phase I and Phase II are shown for the California and Michigan test fleets. These emission averages and the emission reductions were subjected to statistical tests to evaluate whether a statistically significant reduction in emissions resulted from the service actions and, if so, whether Idle of L.S.S. provided greater emission reductions.

Emission levels before service were generally not equivalent for the Idle and L.S.S. fleets. In Phase I, the Idle fleet had lower emissions than the L.S.S. fleet in California; but higher emissions in Michigan. In Phase II, the Idle fleet had lower HC emission than the L.S.S. fleet in California but higher HC emission than the L.S.S. fleet in Michigan. The Phase II Idle and L.S.S. fleets had equivalent CO emissions. In both Phases, the emissions of vehicles in California and Michigan were different.

By combining the California and Michigan fleets, the Idle and L.S.S. before service means were found to be equivalent for HC, CO and NO_x in both phases. Variances were found to be equivalent except for HC and CO emissions where the Phase II L.S.S. fleet was higher than the Idle fleet. The variances

Table 1-1

SUMMARY STATISTICS FOR ALL VEHICLES
After Second Service - 1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons (gm/mile)					Carbon Monoxide (gm/mile)					Oxides of Nitrogen (gm/mile)				
		Before		After		% Reduction	Before		After		% Reduction	Before		After		% Reduction
		μ	σ	μ	σ		μ	σ	μ	σ		μ	σ	μ	σ	
PHASE I																
California	150															
Idle	75	5.9	5.7	5.0	3.9	15.3	65.3	43.7	55.5	34.5	15.0	2.6	1.5	2.6	1.4	0.0
L.S.S.	75	6.3	5.1	5.0	3.6	20.6	72.2	44.6	64.2	39.7	11.1	2.6	1.5	2.6	1.5	0.0
Michigan	148															
Idle	74	6.7	5.5	5.2	3.5	22.4	84.6	55.9	66.4	34.8	21.5	4.0	2.0	4.1	2.1	-2.5
L.S.S.	74	6.6	5.5	5.3	3.1	20.0	78.0	49.1	61.9	34.8	20.6	4.2	1.9	4.2	1.9	0.0
Combined	298															
Idle	149	6.3	5.6	5.1	3.7	19.0	74.9	50.9	60.9	35.0	18.7	3.3	1.9	3.3	1.9	0.0
L.S.S.	149	6.4	5.3	5.1	3.3	20.3	75.0	46.8	63.1	37.2	15.9	3.4	1.9	3.4	1.8	0.0
PHASE II																
California	150															
Idle	75	7.9	8.4	6.0	4.7	24.1	93.0	51.4	80.0	41.8	14.0	3.4	1.7	3.3	1.6	2.9
L.S.S.	75	8.8	11.7	5.2	2.5	40.9	96.2	66.1	70.7	39.1	26.5	3.1	1.7	3.3	1.5	-6.5
Michigan	150															
Idle	75	8.6	9.2	6.4	4.4	25.6	86.2	42.9	73.7	39.1	14.5	4.1	1.6	4.3	1.7	-4.9
L.S.S.	75	6.7	7.0	5.1	2.2	23.9	85.8	41.8	71.0	36.1	17.2	4.0	1.5	4.0	1.5	0.0
Combined	300															
Idle	150	8.2	8.8	6.2	4.6	24.4	89.6	47.3	76.9	40.5	14.2	3.7	1.7	3.8	1.7	-2.7
L.S.S.	150	7.8	9.7	5.2	2.4	33.3	91.0	55.4	70.8	37.5	22.2	3.5	1.7	3.6	1.5	-2.9

Table 1-2

SUMMARY STATISTICS FOR SERVICED VEHICLES ONLY
After Second Service - 1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons (gm/mile)					Carbon Monoxide (gm/mile)					Oxides of Nitrogen (gm/mile)				
		Before		After		% Reduction	Before		After		% Reduction	Before		After		% Reduction
		μ	σ	μ	σ		μ	σ	μ	σ		μ	σ	μ	σ	
PHASE I																
California	43															
Idle	22	8.5	7.4	5.4	2.3	36.5	96.3	46.0	62.6	30.1	35.0	2.3	1.9	2.3	1.6	0.0
L.S.S.	21	10.0	6.1	5.3	2.8	47.0	98.7	49.8	70.3	43.8	28.8	2.0	1.3	1.9	1.4	5.0
Michigan	50															
Idle	24	9.2	7.1	4.4	1.7	52.2	116.4	77.2	60.3	37.3	48.2	3.7	1.8	4.1	1.9	-10.8
L.S.S.	26	10.3	7.5	6.5	4.2	36.9	112.4	50.1	66.7	29.5	40.7	3.4	1.7	3.4	1.4	0.0
Combined	93															
Idle	46	8.9	7.1	4.9	2.0	44.9	106.8	64.3	61.4	33.7	42.5	3.0	2.0	3.3	2.0	-9.1
L.S.S.	47	10.2	6.9	5.9	3.6	42.2	106.3	49.9	68.3	36.2	33.7	2.8	1.7	2.7	1.6	3.6
PHASE II																
California	55															
Idle	26	13.2	12.5	7.8	7.2	40.9	124.9	60.0	87.5	49.9	29.9	2.6	1.5	2.5	1.2	3.8
L.S.S.	29	15.5	16.8	6.2	3.3	60.0	138.3	82.3	72.1	47.4	47.9	2.5	1.8	3.0	1.5	-20.0
Michigan	44															
Idle	22	14.3	14.5	7.1	5.6	50.3	107.1	38.9	64.4	30.5	39.9	4.0	1.9	4.7	2.0	-17.5
L.S.S.	22	10.3	11.9	4.8	2.1	53.4	108.4	40.1	57.8	23.6	46.7	3.5	1.4	3.7	1.3	-5.7
Combined	99															
Idle	48	13.7	13.3	7.5	6.5	45.3	116.7	51.7	76.9	43.3	34.1	3.3	1.8	3.5	1.9	-6.1
L.S.S.	51	13.3	15.0	5.6	2.9	57.9	125.4	68.5	65.9	39.3	47.4	2.9	1.7	3.3	1.4	-13.8

were higher because of a few very high emitters. The high emitters also raised the means but not enough to result in statistically significant differences. The serviced vehicle fleet emission means for HC in Phase I and CO in Phase II were still not equivalent even after combining the California and Michigan fleets. However, the total vehicle fleets were equivalent when California and Michigan vehicles were combined. Therefore, the remainder of this section discusses only the combined California and Michigan fleets in each Phase.

Emission reductions for Idle were 19% for HC and 19% for CO in Phase I compared to 24% for HC and 14% for CO in Phase II. L.S.S. emission reductions were 20% for HC and 16% for CO in Phase I compared to 33% for HC and 22% for CO in Phase II. Idle was equally effective as L.S.S. in Phase I. In Phase II, L.S.S. was 1.4 times more effective in reducing HC emissions and 1.6 times more effective in reducing CO emissions as Idle. Neither regime made a significant change in NO_x emission.

For the serviced vehicle fleet, Idle achieved HC emission reductions of 45% in both Phase I and Phase II. During Phase I, Idle achieved a [illegible]% reduction in CO emissions compared to 34% in Phase II. L.S.S. achieved 42% HC emission reduction in Phase I compared to 58% in Phase II. L.S.S. achieved 34% CO emission reduction in Phase I compared to 47% in Phase II. During Phase I, Idle and L.S.S. were equally effective in reducing HC emissions but Idle was 1.3 times more effective in reducing CO emissions than L.S.S. During Phase II, L.S.S. was 1.3 times more effective in reducing HC and 1.4 times more effective in reducing CO emissions than Idle.

The emission reductions were tested by the covariance analysis which provides a statistical measure of emission reduction shown on each vehicle. This analysis permits selection of the test regime which provides the statistically largest emission reduction. The covariance test, shown in Table 1-3, indicated that Idle and L.S.S. were equally effective in reducing emissions in Phase I but that L.S.S. provided statistically greater emission reductions of HC and CO in Phase II for the total vehicle fleet. For the serviced vehicle fleet, Idle and L.S.S. were statistically equally effective in reducing emissions except that L.S.S. was statistically more effective in reducing CO than Idle in Phase II. Neither Idle nor L.S.S. resulted in statistically significant changes in NO_x emissions.

1.4.2 Effectiveness Index

The emission reductions achieved by Idle and L.S.S. were applied to the effectiveness model. The results of the effectiveness model are shown in Table 1-4 for the combined California and Michigan fleets in each Phase. The model provided a method of calculating annual reductions of total emissions by accounting for distributions of vehicle make, emission reductions, and mileage accumulation, and vehicle age. The model is described in detail in paragraph 2.3.3.4 and the results discussed in detail in paragraph 3.2.5.

The first year (1973) effectiveness for L.S.S. was 10% lower in Phase I but 65% greater in Phase II than Idle. Idle effectiveness decreased slightly (10%) from Phase I to Phase II while L.S.S. effectiveness increased over 100%.

Table 1-3

TESTS OF SIGNIFICANCE OF EMISSION REDUCTION
95% Level of Significance

Vehicle Fleet	Phase I			Phase II		
	HC	CO	NO_x	HC	CO	NO_x
All Vehicles	B	B	N	L	L	N
All Serviced Vehicles	B	B	N	B	L	N

B Indicates both regimes provided statistically significant but equal reduction

L Indicates Loaded Steady State provided statistically greater emission reduction than Idle

N Indicates neither regime provided statistically significant emission reduction

Table 1-4

FIRST YEAR EFFECTIVENESS INDEX - 1975 CVS DATA
Equal Pollutant Weighting - Tons Per Year Reduction

Vehicle Fleet	Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.
All Vehicles	17,500	16,000	19,400	32,900

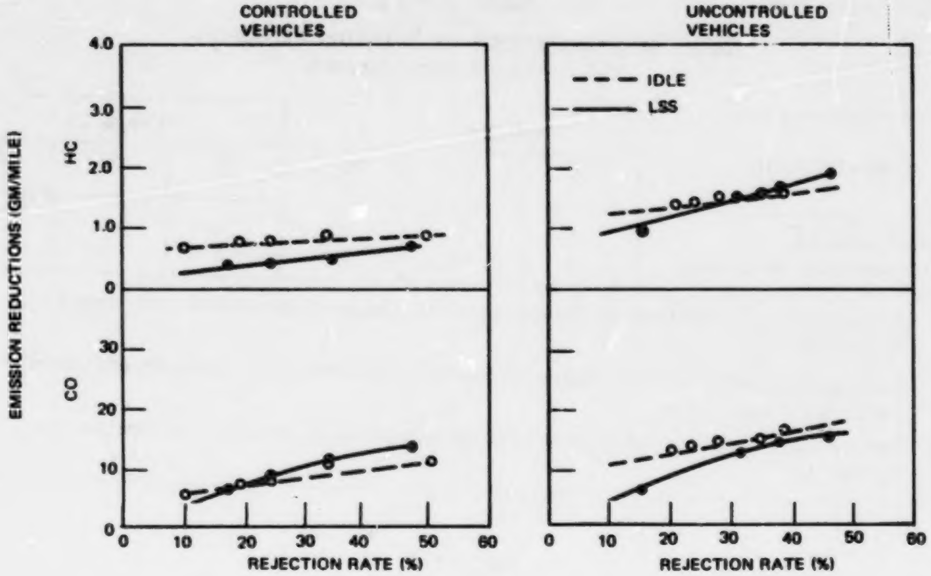
The increased effectiveness in Phase II for the L.S.S. regime was due to very large emission reductions in the California fleet achieved because of correct interpretation of the diagnostic information contained in the pattern of HC and CO failures during the L.S.S. inspection test.

1.4.3 Emission Reductions as a Function of Failure Rate

The California and Michigan data were combined for each phase and rejection limits were applied to the respective inspection test data to fail from 10% to 50% of the Phase I and Phase II vehicle fleets. The rejection limits were based on KEYMODE rejection values suggested by the Clayton Manufacturing Co. for controlled and uncontrolled vehicles. Figure 1-1 presents this data.

In Phase I, Idle and L.S.S. were equally effective in reducing HC emissions from uncontrolled vehicles and CO emissions from controlled vehicles. Idle was slightly more effective in reducing HC emissions from controlled vehicles and CO emission from uncontrolled vehicles than L.S.S. Reductions by both Idle and L.S.S. were not much higher at 50% rejection than at 30% rejection.

CALIFORNIA AND MICHIGAN 1975 CVS DATA
PHASE I



PHASE II

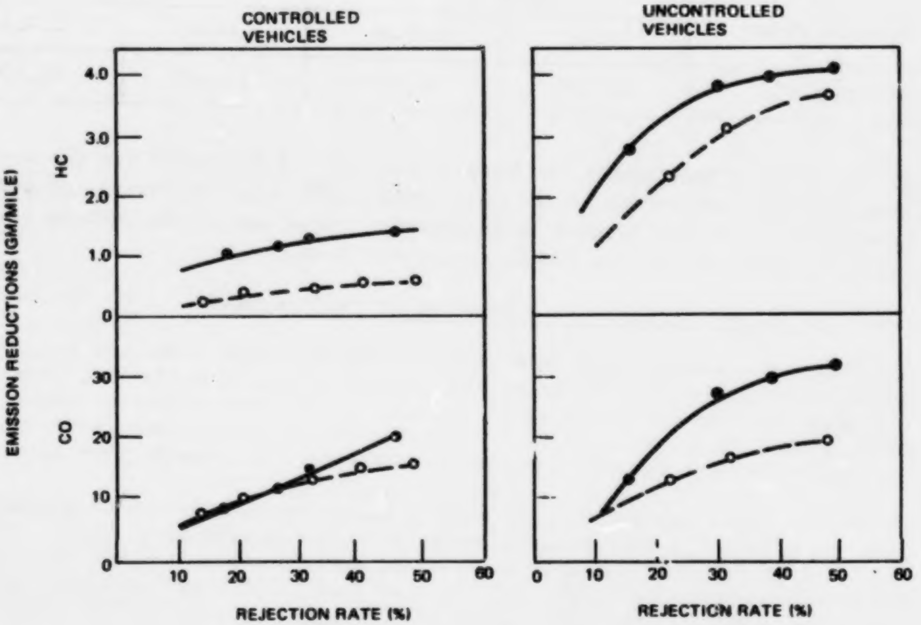


Figure 1-1. Effectiveness as a Function of Rejection Rate

In Phase II, L.S.S. was nearly twice as effective as Idle in reducing CO emissions from uncontrolled vehicles and HC emissions from controlled vehicles. L.S.S. was 15% to 20% more effective than Idle in reducing HC emissions from uncontrolled vehicles. L.S.S. was marginally more effective than Idle in reducing CO emissions from controlled vehicles above 30% rejection rate. The HC and CO emission reductions from both Idle and L.S.S. were not improved much by rejection rates higher than 30%.

1.4.4 Effectiveness of Repairing Idle Only Failures

Idle and L.S.S. PVIM were evaluated to determine if they were equally effective in reducing emissions from vehicles which had emission failures only at idle. This analysis provided a basis of evaluating the cost effectiveness of correcting idle malfunctions only. L.S.S. vehicles were evaluated using the three L.S.S. modes. Idle vehicles were evaluated using Idle and the two cruise modes of the L.S.S. The results of this analysis are presented in Table 1-5 in terms of grams per mile reductions for the total fleet. These emission reductions can be compared to the emission reductions shown in Table 1-1.

Table 1-5

EMISSION REDUCTIONS FROM CORRECTING IDLE FAILURES ONLY
1975 CVS DATA (Grams Per Mile)

Vehicle Fleet	Phase I				Phase II			
	HC	CO	NO_x	Σ	HC	CO	NO_x	Σ
Idle	0.45	5.23	-0.02	5.66	0.40	6.64	-0.04	7.00
L.S.S.	0.70	8.38	-0.02	9.06	0.60	8.83	-0.03	9.40

L.S.S. was 50% more effective than Idle in reducing HC and CO emissions in both Phase I and Phase II. Idle and L.S.S. were equally ineffective in changing NO_x emissions. Correcting vehicles with idle only inspection failures contributed 40% of the HC and CO emission reductions achieved by Idle in Phase I. Correcting vehicles with idle only inspection failures contributed 54% of the HC and 70% of the CO emission reductions achieved by Phase I L.S.S. During Phase II 29% of the HC and 52% of the CO emission reductions for Idle and 22% of the HC and 44% of the CO emission reductions for L.S.S. were achieved by repairing vehicles with only idle emission failures.

1.5 RESULTS OF MAINTENANCE ANALYSIS

Idle and L.S.S. vehicles were reviewed to establish the reasons for emission failure, the maintenance which would have brought them into compliance, the maintenance actually performed, the incidence of unnecessary or excessive repairs, and the incidence of vehicles which were not repairable. Differences in initial fleets and garage performance were summarized for Phase I and II.

1.5.1 Modal Failures

Table 1-6 presents the modal distribution of L.S.S. failed vehicles. Sixty seven (67%) percent of the failed Phase I and 56% of the failed Phase II L.S.S. vehicles failed only at idle. Idle plus cruise mode failures occurred for 18% of the Phase I and 36% of the Phase II L.S.S. vehicles. Cruise mode only failures occurred for 15% of the Phase I and 8% of the Phase II L.S.S. vehicles. An Idle inspection would therefore have failed 85% of the Phase I and 92% of the Phase II vehicles which had failed the L.S.S. inspection test. Cruise mode failures indicating potentially high excess emissions occurred on 33% of the Phase I and 44% of the failed Phase II L.S.S. vehicles. The majority of failures in both Phases and for all modes were for CO or HC plus CO.

Table 1-6

MODAL FAILURE OF L.S.S. VEHICLES
Percent of Failed Vehicles Before Service

Vehicle Fleet	Idle Only		Idle and Cruise		Cruise Only	
	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
All Vehicles	67%	56%	18%	36%	15%	8%

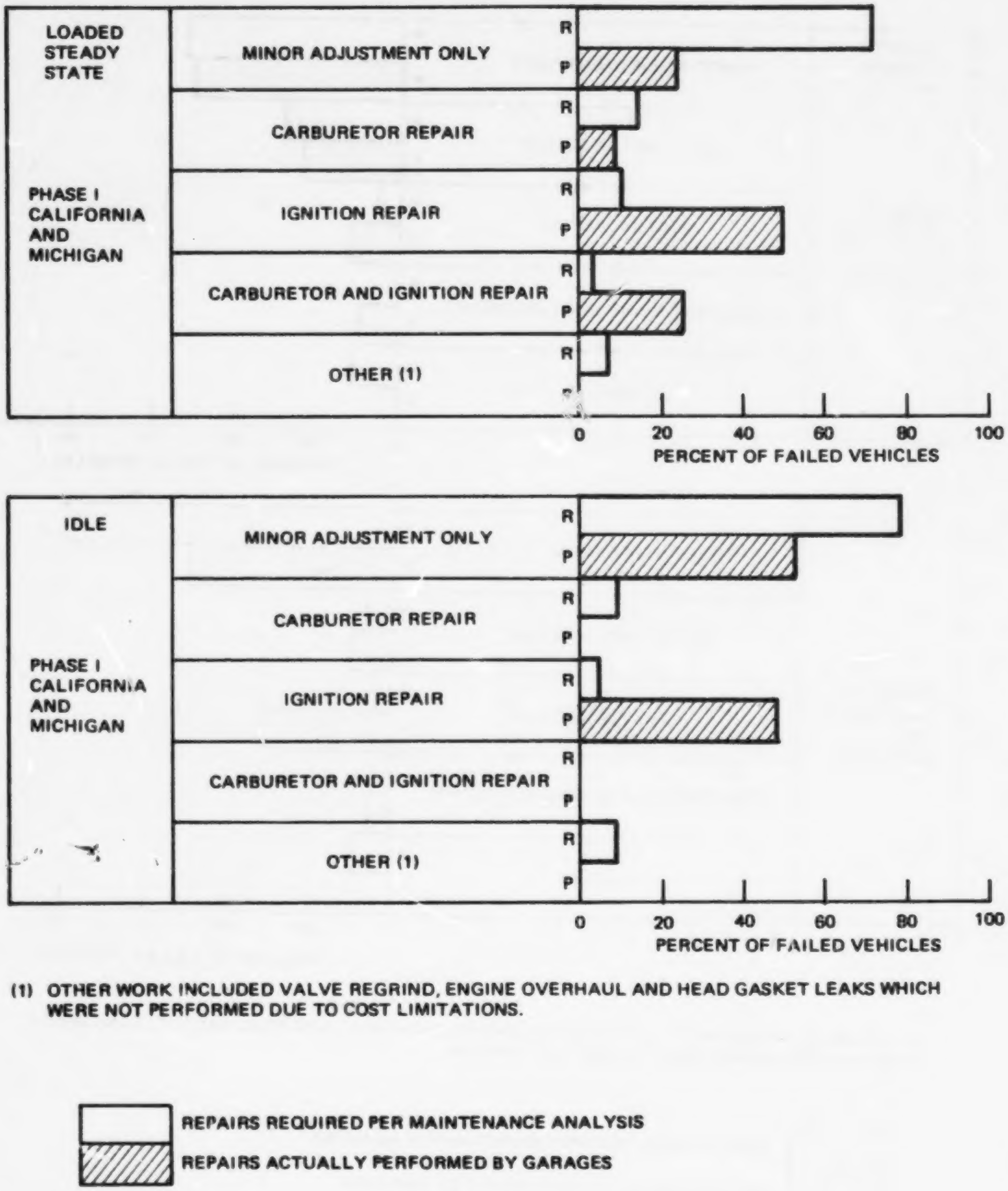
Approximately 63% of the failed Idle vehicles failed at idle for CO only in both Phases. Approximately 73% of the failed Idle vehicles failed CO and HC plus CO in both Phases.

1.5.2 Diagnosis of Failed Vehicles

The minimum amount of work which should have resulted in the failed vehicles passing their inspection test are summarized in Figures 1-2 and 1-3 for Phases I and II respectively. Approximately 80% of the Idle vehicles could have been corrected with only an idle mixture and timing adjustment. Seventy (70%) percent of the failed L.S.S. Phase I and 54% of the failed Phase II vehicles could have been repaired with only idle mixture and timing adjustments. Many of the idle plus cruise failures represent idle mixture richness carried into the low cruise mode.

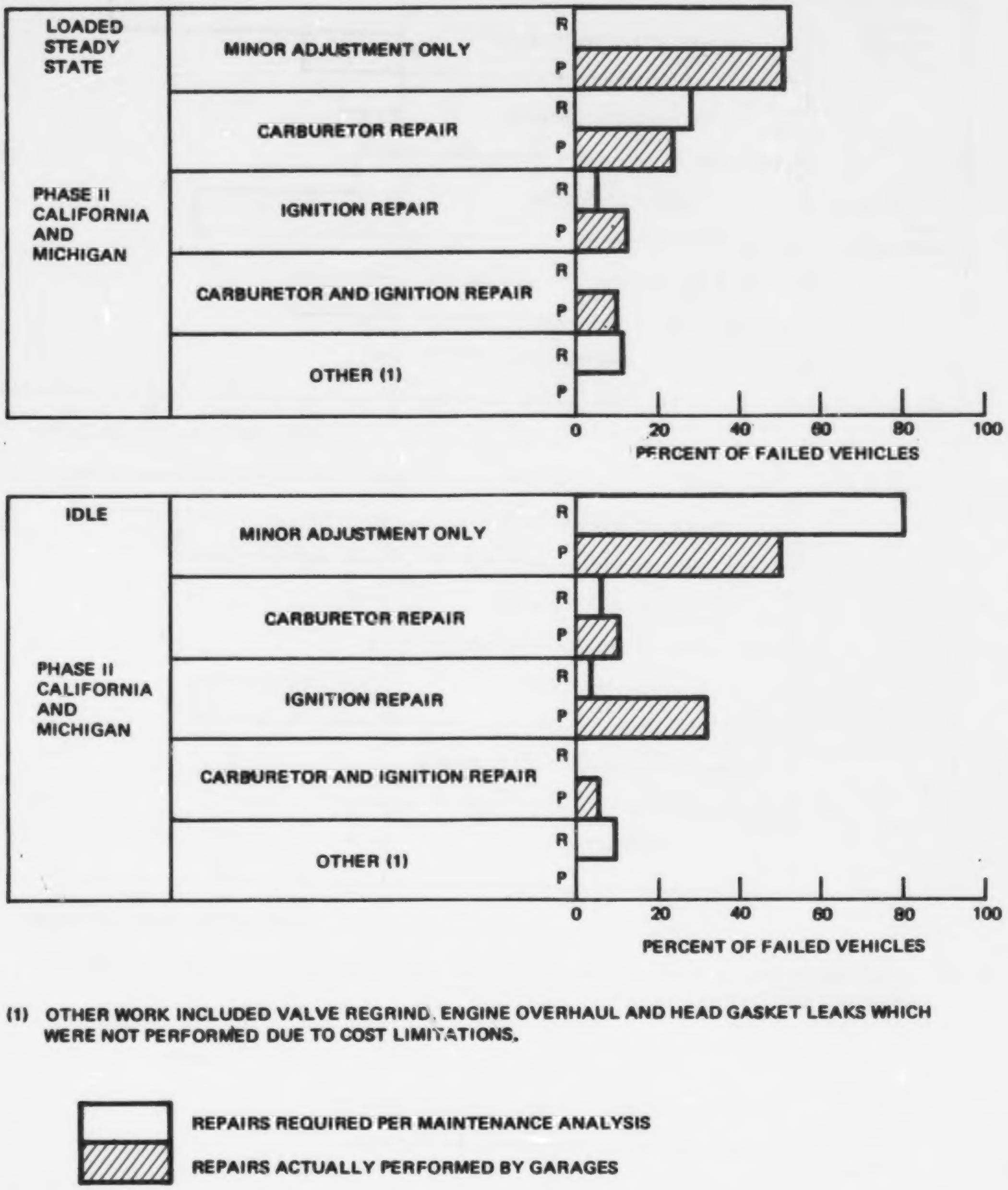
True ignition failures were rare in all test fleets; averaging 4% for Idle and 8% for L.S.S. Ignition repairs were performed for many cases of marginal HC failure, particularly in Phase I, which were actually due to other factors such as carburetion, valves or vacuum leaks. The criteria for ignition misfire was HC emissions greater than 1500 ppm HC. If a lower emission level had be been used, more ignition failures would have been diagnosed.

Carburetor repair was required by 9% of the failed Phase I and 6% of the failed Phase II Idle vehicles. Carburetor repair was required by 15% of the Phase I and 29% of the failed Phase II L.S.S. vehicles. The emission reductions of CO would, therefore, be expected to be greater for L.S.S. in Phase II than in Phase I and greater than Idle in either Phase.



(1) OTHER WORK INCLUDED VALVE REGRIND, ENGINE OVERHAUL AND HEAD GASKET LEAKS WHICH WERE NOT PERFORMED DUE TO COST LIMITATIONS.

Figure 1-2. Comparison of Repairs Required and Repairs Performed to Pass the Emission Inspection Tests – Phase I



(1) OTHER WORK INCLUDED VALVE REGRIND, ENGINE OVERHAUL AND HEAD GASKET LEAKS WHICH WERE NOT PERFORMED DUE TO COST LIMITATIONS.

Figure 1-3. Comparison of Repairs Required and Repairs Performed to Pass the Emission Inspection Tests – Phase II

1.5.3 Repair Action Summary

The actual work performed by the service centers is also shown in Figures 1-2 and 1-3. Both Idle and L.S.S. service centers performed more extensive work, particularly ignition repair, than diagnosed as necessary to achieve compliance. During Phase I, 52% of the failed Idle vehicles and only 22% of the failed L.S.S. vehicles received idle adjustment and or minor parts replacement. During Phase II, 50% of the failed Idle and 52% of the failed L.S.S. vehicles received Idle adjustments.

Ignition repairs were performed much more frequently by Idle service centers in both Phases and L.S.S. service centers in Phase I than required by the emission malfunctions of the vehicles. During Phase II, L.S.S. service centers performed fewer ignition repairs than Idle service centers in either Phase or the L.S.S. service centers in Phase II.

Carburetor repairs were not performed on any Phase I Idle vehicles although 10% had been diagnosed as requiring them. In Phase II, Idle garages performed considerably more carburetor and carburetor plus ignition repair than actually required. In Phase I, L.S.S. service centers performed twice as much carburetor repair than required, but during Phase II performed only slightly more work than diagnosed as required.

Various major mechanical repairs which had been diagnosed as being required to pass the vehicles were not performed because of program cost restrictions.

1.5.4 Excess Repairs

Both Idle and L.S.S. garages tended to perform excess repairs. The excess repairs were predominately replacement of ignition components which appeared to be in "poor or bad" condition but which did not result in ignition misfire.

The incidence of excess L.S.S. repairs in Phase II (23%) were less than one-half of that occurring in Phase I (65%). Excess repairs for Idle were not significantly different in Phase I (48%) and Phase II (42%). The improved L.S.S. performance was attributed to correct application of the diagnostic information in the L.S.S. test by the Phase II garages.

Even during Phase II, however, the excessive repairs (primarily electrical) occurred to 28% of the serviced Idle vehicles and 17% of the L.S.S. vehicles. This was due in part to the past experience of mechanics who practice preventive maintenance (replacement) of the electrical system rather than emission failure maintenance. It was also likely that instructions did not adequately distinguish ignition misfire from other malfunctions which cause moderately high HC emissions such as lean mixtures, rich mixture, oil consumption (blow-by) or valve leaks.

Unnecessary carburetor replacements were made on 13% of the Phase I L.S.S. vehicles but only 4% of the Phase II L.S.S. vehicles. Excessive carburetor replacements were performed on only 4% of the Idle vehicles in Phase I and 12% in Phase II. Since the Idle garages did not have cruise mode data, they were not concerned that the problems might include main system failures. Idle adjustments were sufficient to solve most CO emission failures at idle.

1.6 RESULTS OF COST ANALYSIS

This section summarizes the cost analyses performed during the Short Cycle project. The analysis addresses inspection cost and maintenance cost separately.

1.6.1 Inspection Program Costs

The inspection program costs were derived from a previous Northrop Corporation study for the California Air Resources Board (reference 1) as shown in Table 1-7. L.S.S. in a state-operated system was estimated to be approximately 64% more expensive to install than Idle but not significantly more expensive to operate.

Table 1-7

INSPECTION PROGRAM COSTS

	Idle	L.S.S.
Cost per Vehicle*	$ 1.16	$ 1.35
Statewide Investment Cost		
California	$12,084,000.00	$19,830,000.00
Michigan	6,646,000.00	10,907,000.00
Statewide Operating Cost		
California	$ 9,978,000.00	$10,919,000.00
Michigan	5,500,000.00	5,995,000.00

*Investment cost amortized for 10 years at 6% interest per year

1.6.2 Vehicle Maintenance Cost

Table 1-8 presents the average cost for repairing Idle and L.S.S. vehicles which failed the initial inspection test. The average cost per serviced Idle vehicle was approximately $27 in Phase I and $31 in Phase II. The average cost per serviced L.S.S. vehicle was approximately $37 in Phase I and $31 in Phase II. Idle cost increased in Phase II because of more extensive repair actions required in California. L.S.S. cost decreased in Phase II because fewer excessive repairs were performed in Michigan. An average of approximately $10 per serviced vehicle was identified as excessive cost for Idle in both Phases and for L.S.S. in Phase I. In Phase II, L.S.S. excess repair cost was reduced to an average of approximately $4 per serviced vehicle.

Table 1-9 presents the average cost of performing various typical classes of vehicle maintenance. In general, the average cost of performing a given repair was lower for L.S.S. than for Idle. The average serviced vehicle cost in Phase I was higher for L.S.S. than for Idle because the service centers performed each type of repair more frequently than did Idle. In Phase II, the L.S.S. service centers generally performed only those repairs

Table 1-8

AVERAGE SERVICE COST
Dollars Per Vehicle

Vehicle Fleet	Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.
Cost as Incurred All Vehicles	8.27	11.38	11.37	10.76
Serviced Vehicles	26.78	36.81	31.14	31.03
Less Excess Cost All Vehicles	5.49	8.08	7.04	9.40
Serviced Vehicles	17.77	26.07	21.11	27.11

Table 1-9

AVERAGE COST FOR SERVICE EVENT - ACTUAL COST
Dollars Per Serviced Vehicle

Vehicle Fleet	Minor Adjustments		Minor Parts Replacement		Ignition Repair		Carburetor Repair	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
All Serviced Vehicles								
Phase I	11.43	12.18	7.62	5.66	29.38	25.14	8.50	25.57
Phase II	12.64	9.48	6.33	6.09	24.15	22.87	38.62	36.62

suggested by the diagnostic information of the L.S.S. test and, therefore, achieved lower serviced vehicle cost as well as lower service event cost than idle.

Table 1-10 presents the average cost of correcting those vehicles with only idle emission failures. These vehicles represented approximately 60% of the failed vehicles. During Phase I, Idle repair cost was $29 per serviced vehicle compared to $32.50 for L.S.S. During Phase II, Idle repair cost was $27 per serviced vehicle compared to $17 for L.S.S. The cost for repairing Idle vehicles in both Phases was approximately equal to the cost of an ignition tuneup as shown in Table 1-9. The cost of L.S.S. in Phase I was higher than the average cost of ignition repair, reflecting the large number of excessive repairs in L.S.S. The cost of L.S.S. in Phase II, however, was approximately equal to the sum of replacement of minor parts and labor for minor engine adjustments for L.S.S. as shown in Table 1-9. The diagnostic information of the L.S.S. test, when correctly utilized, limited repair effort and resulting cost to the malfunctioning idle system components and adjustments.

Table 1-10

AVERAGE REPAIR COST OF CORRECTING IDLE ONLY FAILURES
Dollars Per Serviced Vehicle

Vehicle Fleet	Phase I	Phase II
All Vehicles		
Idle	4.89	5.24
L.S.S.	7.32	3.43
All Serviced Vehicles		
Idle	29.13	27.13
L.S.S.	35.20	17.71

Figures 1-4 and 1-5 present the average repair cost as a function of failure rate for Phase I and Phase II respectively. During Phase I, Idle was less expensive than L.S.S. at all rejection rates. During Phase II, L.S.S. was more costly for controlled vehicles than Idle at all rejection rates but slightly less costly for uncontrolled vehicles.

1.6.3 Total Program Cost

Table 1-11 presents the total annual program cost for statewide implementation of Idle and L.S.S. The data represent the sum of California and Michigan costs for Phase I and Phase II. The total program cost is based on the inspection program cost (Table 1-7) and the maintenance cost (Table 1-9). The total program cost was determined by multiplying the cost of inspection and repair averaged over all vehicles in each state's test fleet by the corresponding vehicle population. The privately owned vehicle population in California and Michigan was estimated to be 10 million vehicles and 5.5 million vehicles respectively.

Table 1-11

FIRST YEAR TOTAL PROGRAM COST - COMBINED STATES
Millions of Dollars

Cost Element	Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.
Inspection	18	21	18	21
Maintenance	126	165	169	185
Total	144	186	187	206
Capital cost amortized over 10 years at 6% interest				

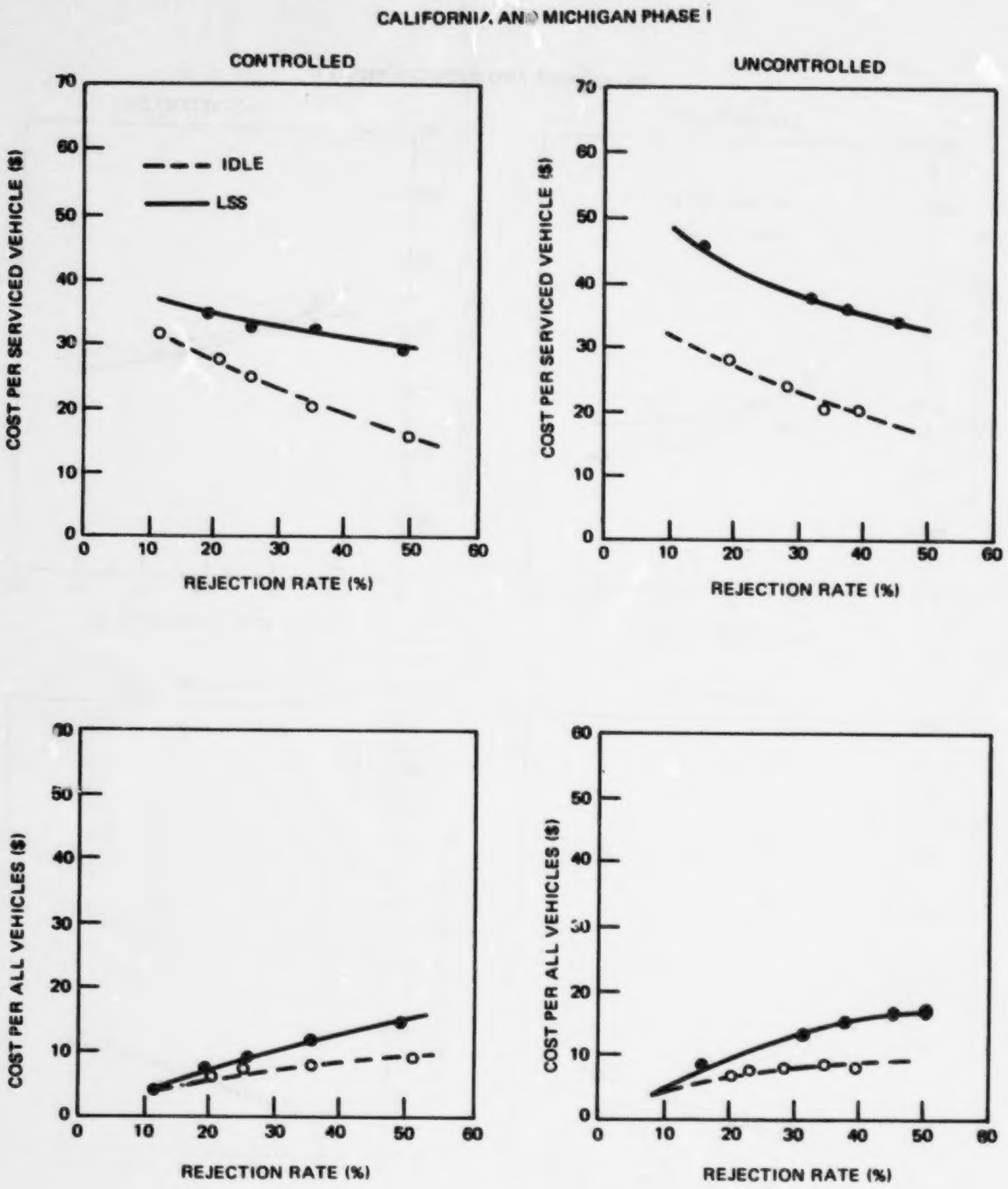


Figure 1-4. Average Vehicle Repair Costs – Phase I

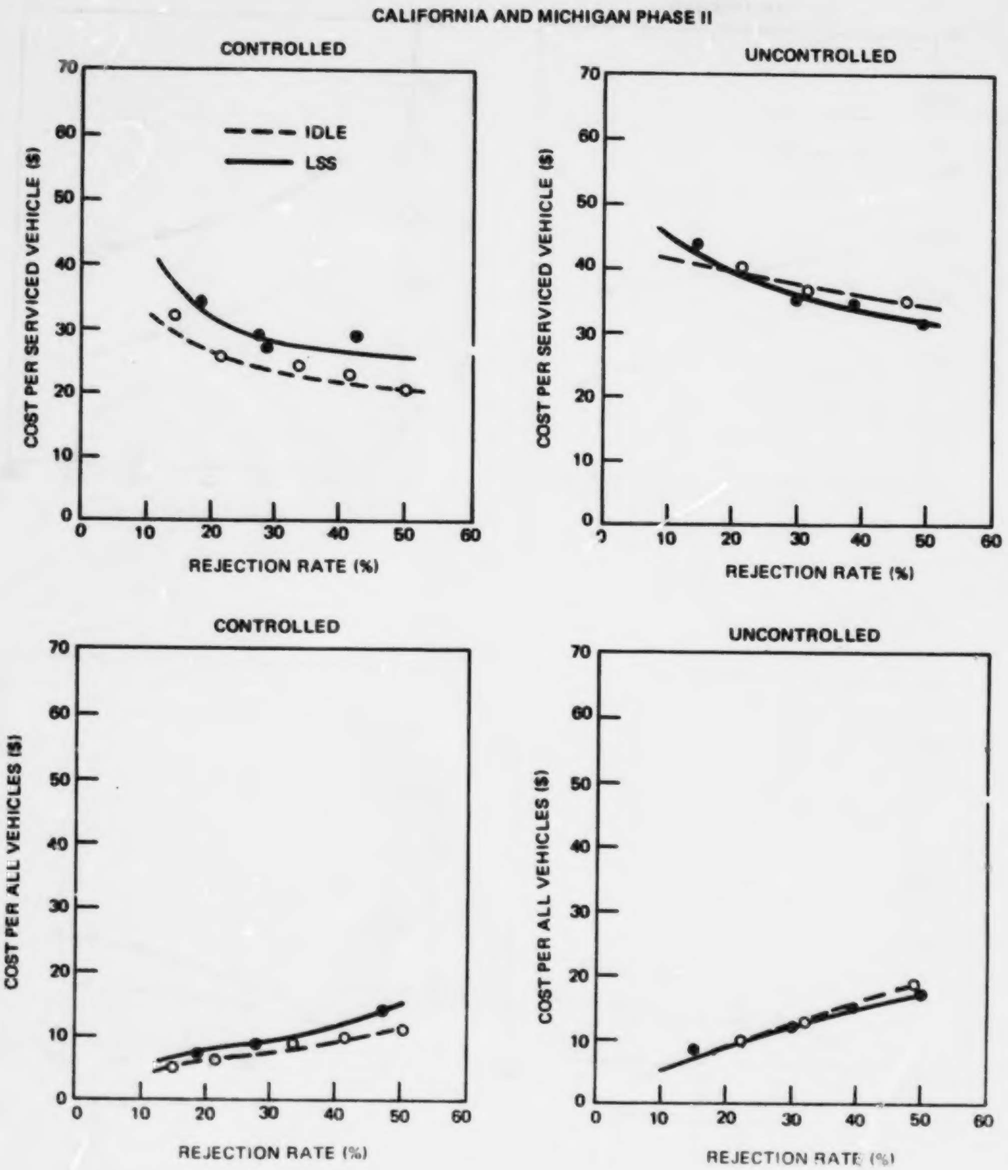


Figure 1-5. Average Vehicle Repair Costs — Phase II

As shown in Table 1-11, the cost of inspection, assuming 10 year amortization of capital costs, was approximately 10% of the total program cost. L.S.S. was found to be 30% more costly during Phase I but only 10% more costly during Phase II than Idle. Total annual cost for Idle was estimated to be $144 million in Phase I and $187 million in Phase II. Total annual cost for L.S.S. was estimated to be $186 million in Phase I and $206 million in Phase II. The differences in total program cost between Phase I and Phase II was due to differences in vehicle owner cost of repair.

Table 1-12 summarizes the average annual vehicle owner cost based on the average of California and Michigan maintenance cost. The owner of a passing vehicle would pay only the cost of inspection, which was estimated to be under $1.50 per year if performed at a high-volume state owned inspection facility. The owner of a failed vehicle would pay the cost of inspection, plus the cost of corrective maintenance. Thus, the owner of a failed Idle regime vehicle would pay approximately $28 based on Phase I and $32 based on Phase II. The owner of a failed L.S.S. regime vehicle would pay approximately $38 based on Phase I and $32 based on Phase II. During Phase II, the vehicle owner cost was essentially the same for both Idle and L.S.S. vehicles.

Table 1-12

ANNUAL VEHICLE OWNER COST - COMBINED STATES
Dollars Per Vehicle

Cost Element	Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.
Passed Vehicle	1.16	1.35	1.16	1.35
Failed Vehicle	27.94	38.16	32.30	32.38

1.7 RESULTS OF THE COST EFFECTIVENESS ANALYSIS

This section summarizes the results of the cost effectiveness analysis and combines the results of Section 1.4 (Effectivenss) and 1.6 (Cost). Cost effectiveness has been calculated in two ways: 1) Fleet Cost Effectiveness which addresses only the cost effectiveness of the test fleet and 2) Cost Effectiveness Index which combines the Effectiveness Index and Total Program Costs. The Fleet Cost Effectiveness was calculated in terms of emission reduction (grams per mile) per maintenance cost for various failure rates and for those vehicles with only idle failures. The Cost Effectiveness Index was calculated in terms of annual pounds of emission reduction per dollar of program cost.

1.7.1 Fleet Cost Effectiveness

Table 1-13 presents the cost effectiveness of correcting only those vehicles with idle emission failures. These vehicles represent the largest group of both Idle and L.S.S. regime vehicles, L.S.S. was more cost effective than Idle in correcting vehicles with only idle malfunctions in both Phases of the program. During Phase I, L.S.S. was approximately 40% more cost effective than Idle. During Phase II, L.S.S. was twice as cost effective as

Idle. This indicates that the diagnostic information conveyed by the L.S.S test can significantly improve the service industries ability to correct simple failures at low cost.

Table 1-13

COST EFFECTIVENESS OF CORRECTING IDLE FAILURES ONLY
Gram Per Mile Reduction Per Dollar

Vehicle Fleet	Phase I	Phase II
Idle	1.14	1.34
L.S.S.	1.24	2.74

Effectiveness values from Table 1-5.
Cost values from Table 1-10 for All Vehicles.

Figure 1-6 presents the cost effectiveness of emission reduction at rejection rates from 10% to 50%. In Phase I, Idle was found to be more cost effective than L.S.S. at all rejection rates for correcting HC and CO emission failures on uncontrolled vehicles and HC emission failures on controlled vehicles. Idle and L.S.S. were equally cost effective in repairing CO emission failures on controlled vehicles. In Phase II, L.S.S. was more cost effective than Idle at all rejection rates for correcting HC and CO emission failures on uncontrolled vehicles and HC emission failures of controlled vehicles. Idle and L.S.S. were equally cost effective in repairing CO emission failures on controlled vehicles. The improved L.S.S. performance in Phase II resulted from the higher emission reductions and lower repair cost achieved by using the L.S.S. diagnostic information.

1.7.2 Cost Effectiveness Index

Table 1-14 presents the cost effectiveness index based on the Effectiveness Index (Table 1-9) and the Total Program Cost (Table 1-11). Data are presented for inspection and repair cost separately. Idle was more cost effective in Phase I than L.S.S. However, in Phase II L.S.S. is more cost effective than Idle. The cost effectiveness of Idle did not change appreciably between Phases. The cost effectiveness of L.S.S., however, increased from Phase I to Phase II. This increase was due to higher emission reductions at low average repair cost. The improved L.S.S. performance was due to the correct use of the L.S.S. diagnostic data by the L.S.S. service centers.

1.8 RESULTS OF THE RELATABILITY ANALYSIS

This section presents the results of the correlation analysis performed on each of the short emission inspection tests relative to the 1975 CVS test procedure. In addition, this section discusses the relatability of Idle and the Loaded Steady State to the 1975 CVS test procedure in terms of the number of commission errors.

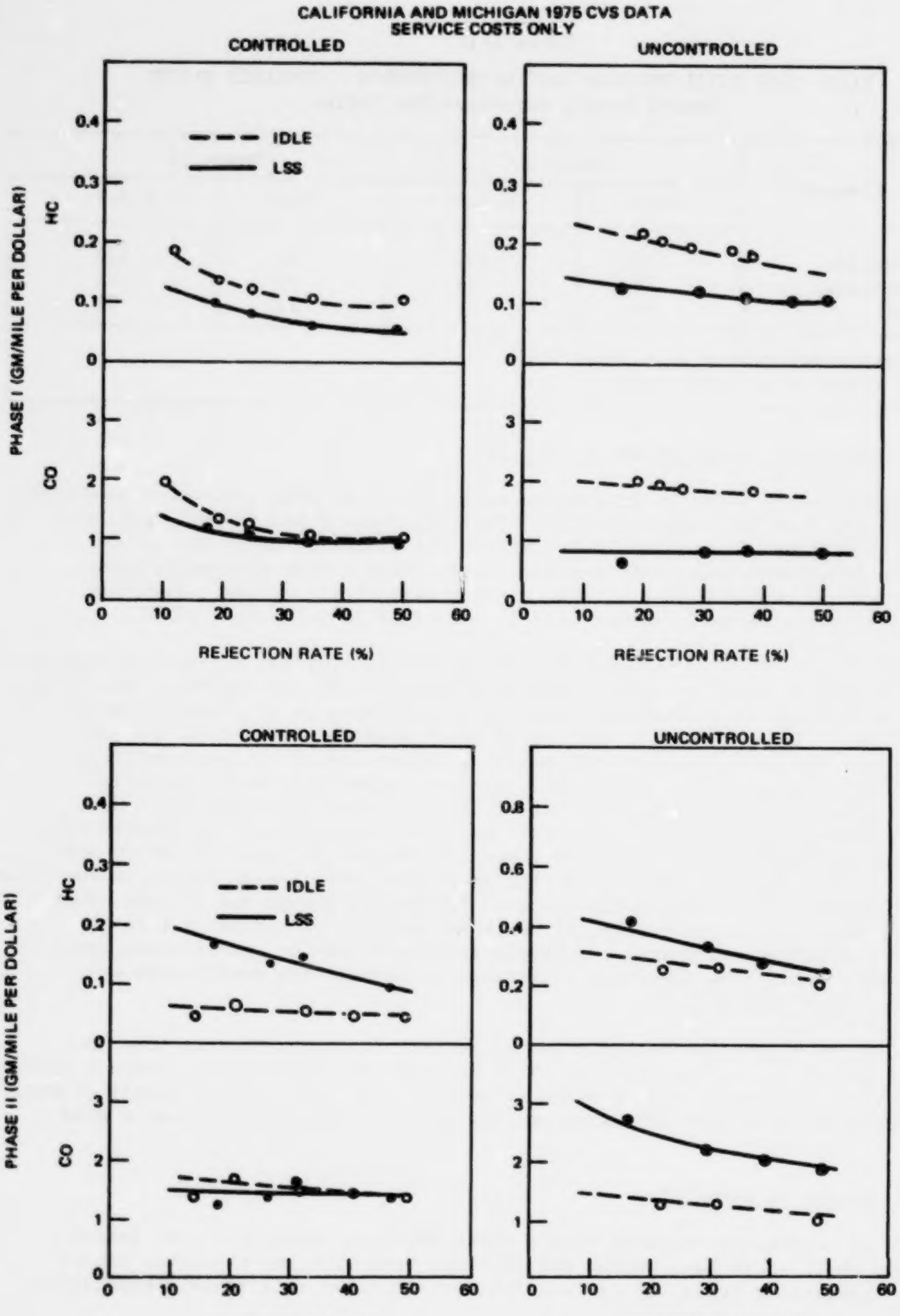


Figure 1-6. Cost Effectiveness as a Function of Rejection Rate

Table 1-14

FIRST YEAR TOTAL PROGRAM COST EFFECTIVENESS - COMBINED STATES
Annual Pounds Reduction Per Dollar

Cost Element	Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.
Inspection	195	153	216	313
Maintenance	28	19	23	36
Total	24	17	21	32

Effectiveness values from Table 1-4.
Cost values from Table 1-11.

1.8.1 Short Test Correlation to 1975 CVS

The various short emission inspection tests listed on page 1-4 were correlated to 1975 CVS data for before-service. Combined Phase I and II data were used since maintenance effects would not affect the correlations of the before-service fleet emissions. The various steady state speeds were correlated singly and in combination utilizing a stepwise multiple linear regression. The correlation analysis methodology is described in paragraph 2.3.6.

The short mass emission inspection tests generally provided better correlation than volumetric short emission inspection tests for HC, CO and NO_x. The 1972 CVS test and the 1975 CVS test were highly correlated in all cases (greater than 0.95). The most highly correlated short emission inspection test was either the EPA Short Cycle or the multiple regression of the mass emission steady state speed data. Volumetric emission inspection tests generally ranked between 5th and 22nd best out of the 22 inspection tests which were ranked relative to the 1975 CVS. Idle was consistently least correlated with correlation coefficients between 0.6 and 0.8 for HC; 0.5 and 0.6 for CO and less than 0.1 for NO_x. The L.S.S. (three steady state speeds corresponding to KEY MODE) showed correlation coefficients of 0.8 to 0.9 for HC and CO; and about 0.7 for NO_x. L.S.S. generally, although not always, ranked lower than the 7-mode and volumetric emission multiple regression of the steady state speed volumetric data. The numerical difference in correlation coefficient was, however, less than 0.1

The multiple regression analysis indicated that inclusion of more than four speeds gained negligible improvement in correlation coefficient. Hence a three or possibly four speed steady state volumetric test will provide nearly as good a correlation with 1975 CVS emission data as can be expected without a mass test.

1.8.2 Errors of Commission

Errors of commission occurred when a short emission inspection test failed a vehicle which would have passed the 1975 CVS test with the rejection limits of the respective tests set to fail the same fraction of a vehicle population.

The analysis consisted of calculating predicted 1975 CVS emission values for each vehicle using the regression coefficients developed from the test program. The predicted 1975 CVS emissions were then ranked and the highest 10% to 50% decile groups of the controlled and uncontrolled vehicles were examined to determine if the actual 1975 CVS value was greater or less than the predicted 1975 value corresponding to the rejection limit for each decile group. If the actual 1975 CVS value was greater than the predicted 1975 CVS value the vehicle represented a valid failure. If the actual 1975 CVS value was less than the predicted 1975 CVS value, the vehicle represented an error of commission.

The analysis indicated that Idle and L.S.S. generally provided the same number of errors of commission. At rejection rates between 30% and 40% of the total population, errors of commission become greater than 10% of all the inspected vehicles. Commission errors for CO were higher for uncontrolled vehicles than controlled. Commission errors for HC were about the same for controlled and uncontrolled vehicles.

Numerical correlation to the 1975 CVS test was not satisfactory for determining pass-fail decisions on individual vehicles for either the Idle inspection or the L.S.S. test.

An alternate definition of commission and omission errors could be proposed based upon the ability of the regime to identify correctable engine system malfunctions or maladjustments independent of CVS emission levels. Using malfunction detection rather than emission measurement as a goal, L.S.S. was found to commit fewer errors of commission than Idle. Idle did not generally commit commission errors but did commit omission errors on vehicles with low idle emissions but excessive power mode emmissions.

1.9 SUMMARY CONCLUSIONS

This section summarizes the principle conclusions resulting from each of the analyses described above.

1.9.1 Effectiveness Analysis

(1.1) Idle inspection and maintenance provided 22% HC and 16% CO emission reduction and no significant change in NO_x for the total fleet immediately after maintenance. Degradation was not considered.

(1.2) Phase I Loaded Steady State (L.S.S.) inspection and maintenance provided 20% HC and 16% CO emission reductions and no significant change in NO_x for the total fleet immediately after maintenance. Degradation was not considered.

(1.3) Phase II L.S.S. inspection and maintenance (based on the "KEY MODE Emission Evaluation System") provided 33% HC and 22% CO emission reductions and no significant change in NO_x for the total fleet immediately after maintenance. Degradation was not considered.

(1.4) Phase II L.S.S. was 50% more effective in reducing HC emissions and 38% more effective in reducing CO emissions than either Idle or Phase I L.S.S. PVIM.

(1.5) Idle and Phase I L.S.S. were statistically equal in reducing emissions for all fleets and at all rejection rates.

(1.6) Phase II L.S.S. provided statistically significant greater emission reductions of HC and CO than Idle PVIM.

(1.7) Phase II L.S.S. provided greater emission reductions than Idle at all rejection rates.

(1.8) Phase II L.S.S. provided greater emission reductions than Idle on vehicles which failed only idle emission limits.

1.9.2 Maintenance Analysis

(2.1) Marginal ignition systems which did not result in ignition misfire were frequently repaired by garages for "preventive maintenance" because of erratic oscilloscope patterns.

(2.2) Most excess repairs were for unncessary ignition component replacement for both the Idle and L.S.S. fleets in this program.

(2.3) Excessive carburetor repairs were performed on L.S.S. vehicles more frequently than on Idle vehicles but defective carburetors were not replaced on Idle vehicles in some cases because the vehicle passed Idle rejection limits.

(2.4) Present repair industry diagnosis and repair procedures did not clearly distinguish the need for minor adjustment from repair and replacement actions. Clear understanding of and proper use of modal failure data provided by the L.S.S. regime permitted the repair facilities to achieve greater emission reduction effectiveness and cost effectiveness than using present repair industry diagnosis even when aided by idle emission measurements.

1.9.3 Cost Analysis

(3.1) Average repair cost for servicing failed Idle vehicles was $26 for uncontrolled vehicles and $28 for controlled vehicles in Phase I. Average repair cost for servicing failed Idle vehicles in Phase II was $36 for uncontrolled vehicles and $22 for controlled vehicles.

(3.2) Average repair cost for servicing failed Phase I L.S.S. vehicles was $39 for uncontrolled vehicles and $32 for controlled vehicles.

(3.3) Average repair cost for servicing failed Phase II L.S.S. vehicles was $34 for uncontrolled vehicles and $25 for controlled vehicles.

(3.4) An approximate average of $10 excessive cost was incurred in repairing failed Idle and Phase I L.S.S. vehicles.

(3.5) An approximate average of $4 excessive cost was incurred in repairing failed Phase II L.S.S. vehicles.

(3.6) Average inspection cost including 10 year amortization of equipment and facilities and annual operation were $1.16 per vehicle for Idle and $1.35 for Loaded Steady State.

1.9.4 Cost Effectiveness Analysis

(4.1) Idle was more cost effective in reducing emissions than Phase I L.S.S.

(4.2) Phase II L.S.S. was more cost effective than Idle or Phase I L.S.S. in reducing emissions.

(4.3) L.S.S. was more cost effective than Idle in reducing emissions of vehicles with only idle inspection failures in both Phases.

(4.4) Diagnostic assistance provided by the L.S.S. test can provide more cost effective repair of emission related engine malfunctions than present industry diagnosis.

1.9.5 Relatability Analysis

(5.1) Neither Idle nor L.S.S. provide sufficiently good numerical correlation to CVS tests to satisfactorily estimate CVS emission levels on individual vehicles.

(5.2) L.S.S. provided better correlation to 1975 CVS and 1972 CVS tests than Idle.

(5.3) Idle and L.S.S. provided approximately the same number of errors of commission for HC and CO emissions based on numerical correlation.

(5.4) The 1972 CVS and 1975 CVS test procedure were nearly perfectly correlated with each other based upon calculating the 1972 CVS data from the first two bags of the 1975 CVS test.

(5.5) The 9-mode Federal EPA Short CVS test was the short emission inspection test which was best correlated to the 1972 CVS and 1975 CVS tests.

(5.6) The Idle test was generally the short emission inspection test which least correlated with the 1972 CVS and 1975 CVS tests.

SECTION 2
TEST PROGRAM METHODOLOGY

This section describes the organization of the Study, vehicle procurement, testing procedures, data reduction, and analysis techniques.

2.1 STUDY TEAM

The "Short Cycle" study team was comprised of Olson Laboratories and the Environmental Systems Department of Northrop Corporation's Electro-Mechanical Division as shown in Figure 2-1. The team members were supported by other departments of Northrop which provided data recording, processing, and analysis. Olson-Horiba, Inc., provided HC and CO NDIR gas analyzers for use by the participating garages. Olson Engineering Services developed vehicle selection lists from Michigan and California vehicle registration data, formulated vehicle procurement procedures, prepared detailed test and data control procedures, and provided program administration.

The Testing Services Division of Olson Laboratories was responsible for all vehicle testing functions. These functions included vehicle procurement, emission testing, data recording and verification.

The data analysis function was provided by the Northrop Environmental Systems Department. This function included generation of data forms and computer format, development of computer programs, and the performance of computer and manual analyses. Additional functions performed by this group were the generation of study results and preparation of the Phase I and Final Reports.

The independent garages, under supervision of Olson's Engineering Services, conducted vehicle maintenance appropriate to each test regime. KEY MODE garage training was provided by Clayton Manufacturing Company during Phase II.

The Environmental Protection Agency's Office of Mobile Source Pollution Control provided policy guidance and program direction. EPA also directed changes in inspection test rejection limits and loaded steady state (L.S.S.) maintenance and training procedures for Phase II. EPA also participated as a member of the technical review board which reviewed and approved technical progress of the project and organization of the Final Report.

2.2 INSPECTION AND MAINTENANCE OPERATIONS

This section discusses program operation. Included are a description of the test fleets utilized in both phases of the study, description of the procedures used to prepare and test each vehicle, and tables showing the emission values selected to pass or fail a vehicle. Figure 2-2 indicates the vehicle flow path during this test program. A discussion of the procedures used to service Idle

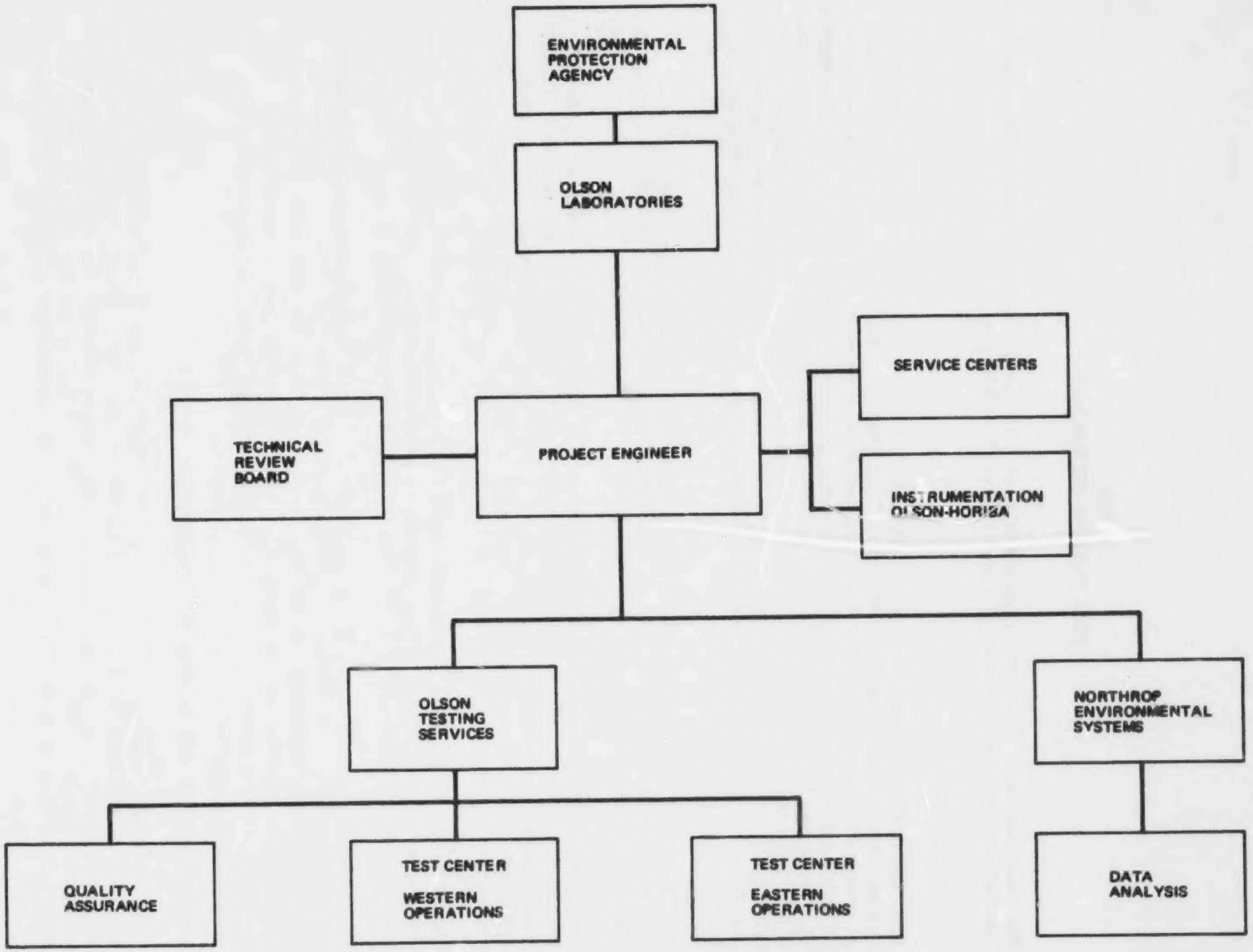
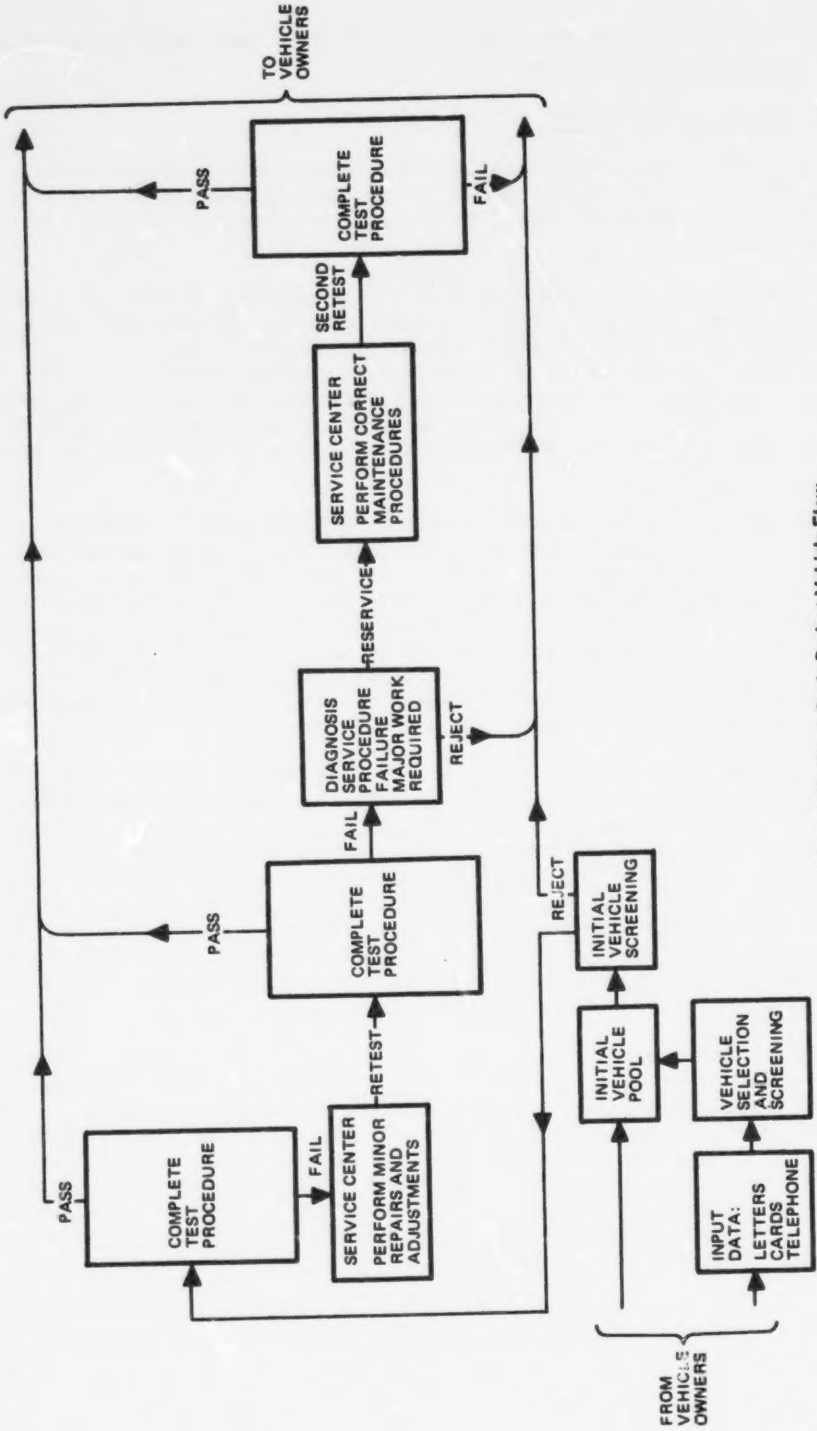

ENVIRONMENTAL PROTECTION AGENCY
OLSON LABORATORIES
TECHNICAL REVIEW BOARD
PROJECT ENGINEER
SERVICE CENTERS
INSTRUMENTATION OLSON-HORIBA
OLSON TESTING SERVICES
NORTHROP ENVIRONMENTAL SYSTEMS
QUALITY ASSURANCE
TEST CENTER WESTERN OPERATIONS
TEST CENTER EASTERN OPERATIONS
DATA ANALYSIS

Figure 2-1. Short Cycle Project Organization



TO VEHICLE OWNERS
PASS
COMPLETE TEST PROCEDURE
FAIL
SERVICE CENTER PERFORM MINOR REPAIRS AND ADJUSTMENTS
RETEST
COMPLETE TEST PROCEDURE
PASS
FAIL
DIAGNOSIS SERVICE PROCEDURE FAILURE MAJOR WORK REQUIRED
RESERVICE
REJECT
SERVICE CENTER PERFORM CORRECT MAINTENANCE PROCEDURES
SECOND RETEST
COMPLETE TEST PROCEDURE
PASS
FAIL
REJECT
INITIAL VEHICLE SCREENING
INITIAL VEHICLE POOL
VEHICLE SELECTION AND SCREENING
INPUT DATA: LETTERS CARDS TELEPHONE
FROM VEHICLE OWNERS

Figure 2-2. Short Cycle Project Vehicle Flow

and L.S.S. test regime vehicles which failed to pass their respective emission test concludes this section.

2.2.1 Vehicle Procurement

Vehicle procurement activities included determination of the vehicle population in the states of California and Michigan, identification of required vehicles, acquisition of privately owned vehicles, and scheduling of the vehicles during the test program.

Both Phase I and II involved testing two groups of 150 vehicles, one each in California and Michigan. Each group was further divided into two groups comprising 75 pairs of essentially identical vehicles. One vehicle of each pair was assigned to the Idle test fleet and the other vehicle was assigned to the L.S.S. test fleet. In this manner, the vehicles assigned to the Idle and L.S.S. regime test fleets were kept as identical as possible. However, the vehicles were not necessarily identical in mechanical condition or emission characteristics.

The 75 vehicles in the test fleet for each state were selected proportionately to vehicle registration data in each state. R. H. Donnelly and R. L. Polk provided registration data by make and model year for vehicles 10 years old or less. Vehicles older than 10 years were grouped as a single entry. This classification of older than 10 years (pre-1962 model year vehicles) was taken as representative of the vehicle population of 1957 to 1961 in Michigan. The data for California, however, were modified slightly to take advantage of the 15 year classification data developed during previous Northrop/Olson studies for the State of California Air Resources Board (Reference 1).

Table 2-1 depicts the percentage mix of vehicles by age for both states. The Michigan population comprised considerably larger proportions of newer vehicles. This differential between states might be expected to affect the fleets' average emissions since there are fewer older vehicles in the Michigan population. This difference, however, is counterbalanced by the two year earlier introduction of hydrocarbon and carbon monoxide control systems in California. Therefore, the fraction of exhaust emission controlled vehicles was approximately the same in each state (50.0 percent in California, 47.6 percent in Michigan). The model years were then grouped as shown to provide larger sample cells and to reflect changes in emission control devices.

These combinations of vehicle makes and model years were referred to as "year-make" groups and are tabulated for the California and Michigan test fleets in Tables 2-2 and 2-3 respectively. Whenever a year-make group contained less than 1.5 vehicles, that year-make group was assigned a zero value. The remaining year-make groups were then progressively adjusted so that each year-make group and the totals for each vehicle make and model year group were multiples of two. This algorithm resulted in 75 pairs (150 vehicles) representing the vehicle population in each state. Similar vehicle fleets were procured and tested for both phases of the study.

Vehicles were obtained by contacting owners of vehicle makes and model years required to satisfy Tables 2-2 and 2-3. The vehicles actually procured were to be matched pairs in the following parameters.

Table 2-1
VEHICLE DISTRIBUTION BY MODEL YEAR

GROUP	Model Year	Percent of Total Vehicle Population	
		CALIFORNIA	MICHIGAN
1	1971 1970	7.3% 7.9	6.8% 12.9
2	1969 1968	9.6 9.1	14.5 13.4
3	1967 1966	8.4 8.9	11.0 10.9
4	1965 1964 1963 1962	10.2 7.9 6.8 5.3	10.6 7.2 5.4 3.5
5	1961 & prior (1957-1961)	18.6	3.8

- Year group
- Make
- Mileage (within 10,000 miles)
- Exhaust emission control system
- Engine displacement (within 50 CID)
- Weight (within 500 lbs.)

In the event that a vehicle could not be matched with its identical pair, and a different pair in the same year-model group could not be obtained, limited types of substitution were permitted (e.g., manual for automatic transmission, station wagon for sedan of same make).

Each vehicle utilized was given a preliminary inspection to ensure that it was properly equipped with the required emission control device and was in acceptable mechanical condition for the test program. Adequate mechanical condition was defined to be that which allowed the vehicle to complete the test sequence, did not affect exhaust gas dilution, and would not have caused a breakdown during the various emission tests. Vehicle conditions which affected safety (i.e., tires) or test accuracy (i.e., leaking exhaust pipe) were cause for either rejection of the vehicle or correction at the discretion of Olson Laboratories.

2.2.2 Emission Testing

The testing functions encompass all activites related to completion of the testing program. These functions include vehicle preparation, installation of the vehicle on the dynamometer, instrument calibration, dynamometer test sequence, data reduction and quality audit. Each of these functions was performed every time a vehicle was tested.

Table 2-2

CALIFORNIA VEHICLE POPULATION*

YEAR-MAKE GROUPS

MAKE	70-71	68-69	66-67	62-65	57-61	Total
Buick	2	2	0	2	2	8
Cadillac	0	2	2	0	0	4
Chevrolet	4	6	4	12	6	32
Chrysler	0	0	0	2	0	2
Dodge	2	2	2	2	0	8
Ford	6	4	6	8	6	30
Mercury	0	0	2	2	2	6
Oldsmobile	0	2	2	2	2	8
Plymouth	0	2	2	2	2	8
Pontiac	2	2	2	4	0	10
AMC	0	2	0	2	2	6
Import	4	4	2	0	0	10
Volkswagen	4	4	4	4	2	18
TOTAL	24	32	26	42	26	150

*This population distribution was utilized for both the Phase I and Phase II fleets.

Table 2-3

MICHIGAN VEHICLE POPULATION*

YEAR-MAKE GROUPS

VEHICLE MAKE	70-71	68-69	66-67	62-65	57-61	TOTAL
Buick	2	4	2	4	0	12
Cadillac	2	0	2	0	0	4
Chevrolet	6	8	6	10	4	34
Chrysler	0	2	0	2	0	4
Dodge	2	2	2	2	0	8
Ford	8	8	6	8	2	32
Mercury	2	2	2	2	0	8
Oldsmobile	2	4	2	4	0	12
Plymouth	2	2	2	4	0	10
Pontiac	2	4	4	4	0	14
AMC	0	2	2	0	0	4
Import	0	2	0	0	0	2
Volkswagen	2	2	2	0	0	6
TOTAL	30	42	32	40	6	150

* This population distribution was utilized for both the Phase I and Phase II fleets.

Before being tested, each vehicle was cold soaked 12 hours in a building with temperatures maintained between 65°F and 86°F. After cold soaking, the vehicle was placed on the dynamometer, fastened and blocked. The fuel line was connected to a container of Indolene 30 and a cooling fan was placed in front of the radiator. All instruments were then calibrated at a zero and span point and placed in a sampling mode. The dynamometer was set for the correct inertia weight and power absorption prior to vehicle installation with a non-test vehicle.

Testing was performed according to the applicable Federal Register for 1972 and 1975 CVS tests and the hot start 7-Mode. In the case of the steady state tests including **KEY MODE** and Idle, the commonly accepted procedures were used. During the tests, instrument deflections and pertinent test data were entered on raw data sheets. In addition to the initial calibration, the CVS instruments were calibrated at a zero and span point before each bag measurement. Vehicle exhausts were simultaneously monitored using the NDIR 7-Mode bench and the CVS instrument bench during the steady state and 7-Mode tests. Fuel measurements were made using a 0-5 pound scale, initial readings being taken after engine start-up at the time the "place in gear" mark appeared on the CVS driver's aid. The final measurement was taken at the "end of test" mark.

Each emission measurement performed during the two hour test sequence is described below:

1972 EPA CVS Driving Schedule from a Cold Start (reference 2) - This is a 23-minute cold start test with CVS bag measurement taken for the cold phase and the hot phase. Separate background air bags were used for each phase. During the hot test phase, the sample bags from the previous cold portion were analyzed. Fuel consumption measurements were taken during this test beginning when the transmission was placed in gear and ending at the "end of test" mark.

1972 EPA CVS Driving Schedule from a Hot Start - The CVS Hot Start is a repeat of the first 505 seconds of the 23-minute cold start driving cycle. The hot start is performed after a 10-minute hot soak on the dynamometer immediately following the CVS cold start. The 1972 cold start, the hot soak and the 1972 hot start comprise the 1975 CVS Cold Start test (reference 3).

Federal EPA Short Cycle Test - The EPA Short Cycle is a 9-Mode CVS test, 125 seconds long, with composite accelerations representative of the 1972 CVS procedure. A sample bag was used and the same background concentrations as previously measured during the 1972 CVS hot start was assumed. The mass emissions were calculated using the following equation:

$$m = \frac{V \cdot d \cdot c}{a}$$

where:

m = mass emissions in grams per mile

a = cycle trip length (.7536 mile)

d = density of exhaust component

c = measured concentration in bag

V = total CVS volume

This equation is similar to the calculation for one test phase of the 1975 CVS procedure.

Loaded Steady State Test (L.S.S.) - The L.S.S. inspection test utilized the KEY MODE inspection test (reference 4). Simultaneous measurements were made using the 7-mode instruments and the CVS mass measurement instruments. The continuous sample tap from the CVS was used to obtain a mass per unit time value. Idle measurements were taken with automatic transmissions in gear. The L.S.S. test was run immediately after the CVS sample bag from the EPA Short Cycle was analyzed. It was also necessary to change the power absorption unit to the horsepower values shown in Table 2-4. Three instrument readings were taken 30 seconds after the vehicle had reached each speed. These values were then averaged to obtain the final value recorded for each mode.

Table 2-4
HORSEPOWER VALUES FOR LOADED STEADY STATE TEST

VEHICLE WEIGHT (LBS)	LOW CRUISE		HIGH CRUISE	
	SPEED (MPH)	LOAD (HP)	SPEED (MPH)	LOAD (HP)
Under 2800	23	5	37	14
2800 - 3800	30	9	45	23
Over 3800	33	11	49	29

Steady-State Tests - The power absorption unit was reset so that the horsepower at 50 mph corresponded to road load for the vehicle's weight. CVS readings were taken simultaneously with the 7-mode bench. Emissions were recorded at zero (transmission in neutral) 10, 20, 30, 40, 50 and 60 mph. Three readings were again taken at each speed and averaged to arrive at the composite value for that speed.

Idle Test - The zero mph speed of the steady state test (transmission in neutral) was utilized for the Idle Test. The engine was not tested at any off-idle condition.

The volumetric measurements for the Idle, L.S.S. and Steady State speeds were used directly in emission averages and statistical analyses in concentration units. The CVS measurements were converted to mass emissions per minute using the following formula:

$$mph = V_o \cdot rpm \cdot c \cdot d$$

mph = mass emissions in grams per minute

V_o = CVS volume per revolution of sample pump

rpm = revolutions per minute of sample pump
c = instantaneous exhaust concentration
d = density of exhaust component

7-Mode Hot Start - The last two complete cycles of the standard 7-Mode (reference 5) test were run with the power absorption unit set at 10 hp at 50 miles per hour. During the 7-Modes, CVS bag samples and NDIR concentration measurements were recorded. The CVS background air sample was recorded. The 7-Mode CVS mass emissions were calculated in the same manner as for the Federal EPA Short Cycle. The cycle trip length was 1.683 miles for two 7-Mode cycles. The volumetric data were converted to grams per mile using the calculation procedure found in the referenced Federal Register.

2.2.3 Vehicle Maintenance

The following paragraphs describe the maintenance procedure for vehicles failing the Idle and L.S.S. inspection test limits. Vehicles which failed the initial inspection test were dispatched to one of the participating garages for the first service (see Figure 2-2). Vehicles were retested after service, and, if found to pass the second inspection test, were returned to their owners. During Phase I, those vehicles which failed the second inspection test were sent back to the repair facility for second service if the mechanical failure was identified as being correctable. During Phase II, the additional service was performed by OLI mechanic technicians. Each vehicle which received the second service was subjected to a third emission test sequence. If the vehicle failed the third emission test, no additional servicing was performed and it was exited from the test system as failing the emission limits.

The vehicles which were diagnosed as requiring valve regrind, rings, or other major mechanical work were exited from the program and returned to their owners without repair, but an estimate of the repair was generated.

The inspection test failure limits used in this program are shown in Table 2-5. The limits were intended to fail 50% to 60% of the test vehicle population of the California and Michigan fleet. The rejection limits selected originally were developed for the California ARB report (reference 1). The Michigan limits were modified during Phase II because the Michigan vehicles exhibited higher idle emissions than California vehicles and consequently failed more frequently. The original failure limits also resulted in fewer controlled vehicles failing the Idle inspection. This resulted in more controlled vehicles in the L.S.S. service fleet than in the Idle fleet. During Phase II the limits were revised, based upon emission data from Phase I, to fail 50% to 60% of the controlled and uncontrolled vehicles of each fleet.

2.2.3.1 Vehicle Service Centers - Vehicle service centers were selected to represent typical repair facilities in each state. Each center was required to have oscilloscopes and infrared hydrocarbon and carbon monoxide meters.

TABLE 2-5. EMISSION INSPECTION FAILURE LIMITS

TEST CENTER LOCATION	TEST PROCEDURE	MODE	UNCONTROLLED*		CONTROLLED			
					AIR PUMP		ENGINE MOD	
			HC	CO	HC	CO	HC	CO
CALIFORNIA PHASE I	L.S.S.	Hi Cruise	550 ppm	3.5%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Lo Cruise	550 ppm	4.5%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Idle	800 ppm	7.0%	300 ppm	4.0%	400 ppm	5.0%
	Idle	Idle	700 ppm	6.0%	250 ppm	4.0%	350 ppm	5.0%
CALIFORNIA PHASE II	L.S.S.	Hi Cruise	500 ppm	3.25%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Lo Cruise	500 ppm	4.0%	300 ppm	3.0%	300 ppm	3.0%
	L.S.S.	Idle	850 ppm	7.0%	300 ppm	4.0%	350 ppm	4.0%
	Idle	Idle	700 ppm	7.0%	250 ppm	3.0%	300 ppm	3.0%
MICHIGAN PHASE I	L.S.S.	Hi Cruise	550 ppm	3.5%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Lo Cruise	550 ppm	4.5%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Idle	800 ppm	8.5%	300 ppm	4.0%	400 ppm	5.0%
	Idle	Idle	700 ppm	8.5%	250 ppm	4.0%	350 ppm	6.0%
MICHIGAN PHASE II	L.S.S.	Hi Cruise	550 ppm	3.5%	300 ppm	2.5%	300 ppm	2.5%
	L.S.S.	Lo Cruise	550 ppm	4.5%	300 ppm	3.0%	300 ppm	3.0%
	L.S.S.	Idle	800 ppm	6.0%	300 ppm	4.0%	400 ppm	5.0%
	Idle	Idle	700 ppm	7.5%	250 ppm	3.5%	350 ppm	5.0%

*Includes crankcase devices.

California service centers were Class A State licensed garages which had participated in the ARB study. The Class A license specified minimum equipment complement and the Class A mechanic's license required a written examination. Michigan service centers were commercial service stations or general garages with ability to perform major ignition and carburetor repairs. The Idle regime and L.S.S. regime service centers received only Idle regime vehicles and L.S.S. regime vehicles, respectively.

Service managers, owners and mechanics of participating service centers were asked to attend a four-hour indoctrination meeting in their respective city. The meetings included a briefing regarding the program objectives, the role of the service centers, the test procedures performed by Olson Laboratories, a demonstration of the inspection test, the data recording and billing procedures. Idle and L.S.S. regime mechanics were given briefings on separate days.

Questions regarding training and supervision of garages during Phase I were subsequently raised following excessive repair costs and ineffective repairs during Phase I. As a result, all garages in the program were changed before the start of Phase II with the intention of starting Phase II with previously unbiased garages. Mechanic training and maintenance procedures were altered as indicated below for the L.S.S. Test.

2.2.3.2 Idle Service Procedure - The Idle maintenance procedure required that the service center inspect the vehicle for emissions of HC and CO with an NDIR exhaust gas analyzer. If these values were greater than the established limit, the vehicle was subjected to minor timing and carburetor idle circuit adjustments. If this was not effective in reducing emission to within the prescribed limits, the garage was to initiate additional diagnosis and repair as deemed necessary. Garages were not constrained as to the type of work they could perform, except that no work should be performed if it would exceed $100 total value or involve major work such as valve regrind, rings, or other engine repairs. Any adjustment or repair which succeeded in reducing the emissions to the emission standard should terminate the service cycle. This procedure encouraged the garages to achieve the specified limits with a minimum of effort. The garages were provided a standard data sheet, shown in Appendix A-1, on which to record inspection test results and the work performed. The Idle service procedure was not changed from Phase I to Phase II.

2.2.3.3 L.S.S. Service Procedure - L.S.S. service centers received a KEY MODE Truth Chart with each vehicle. During Phase I, the L.S.S. garages were initially instructed to attempt adjustments prior to ignition or carburetor repairs in an attempt to minimize emissions. They were, however, instructed to perform the diagnosis and repair actions recommended by the KEY MODE procedure for the failure modes indicated. The L.S.S. rejection limits at idle were provided for use in final adjustments.

These instructions were believed to have caused some confusion among the service centers resulting in some excess repair costs. In addition, some instances of ineffective repairs occurred possibly due to the mechanics terminating maintenance actions when idle readings were within specified limits. After 40% of the Phase I Michigan vehicles had been repaired, the Michigan L.S.S. garages were reinstructed by Clayton personnel emphasizing the use of the Truth Charts in diagnosis.

During Phase II, the data forms for the L.S.S. test and the maintenance procedures were altered to conform with those recommended by Clayton for KEY MODE. Garages were instructed by Clayton representatives to perform work indicated by the Truth Charts and to use the exhaust gas analyzer only as a final adjustment aid. The Clayton Truth Charts and data sheets are shown in Appendix A-2. These instructions encouraged the garages to perform the most effective repair.

During both program phases, the garages were instructed not to exceed $100 repair cost without first obtaining OLI authorization. A few vehicles were repaired at costs in excess of $100, generally for carburetor or carburetor and ignition repairs. This instruction, however, also resulted in non-repair of some particularly expensive carburetors or rebuilding of carburetors instead of replacing them with new carburetors.

2.3 DATA ANALYSIS

Five general analyses were applied to the data for each regime: (1) effectiveness; (2) maintenance action; (3) cost; (4) cost effectiveness; and (5) relatability. The detailed discussion of the analysis methodology is contained in the following section. Each analysis was applied to Phase I and II separately except for relatability which considers only the combined Phases. During the analysis, the data were analyzed at a failure rate of approximately 30% obtained by using level V rejection limits (Table 2-6) for all L.S.S. vehicles and the particular idle values which failed the same number of vehicles as for L.S.S.

2.3.1 Data Acquisition

Figure 2-3 shows the steps of data analyses. As seen in Figure 2-3, original data forms received a quality audit to ensure completeness and to flag obvious errors such as data inversion. Suspect data were compared to strip charts from the test bench to correct any deficiencies. Approved data forms were sent to keypunching and then tested by an error check routine to flag widely variant emission measurements (those approximately beyond the 2-sigma values for the distribution). Those data were reevaluated to ascertain if the vehicle was in fact a very high or low emitter or if errors existed within the data. After any necessary corrections, a computer listing of the complete data set was generated to provide a permanent magnetic tape record for future use.

2.3.2 Fleet Emission Statistics

The emission data were processed to compute the mean value, minimum value, maximum value, and standard deviation of the mean for each subfleet in the program. These were computed for each state, test regime, pollutant and test phase. In addition, data were characterized by the following vehicle parameters:

- Make
- Model year
- Emission control system
- Accumulated mileage
- Vehicle weight
- Engine size

Table 2-6

REJECT LEVELS FOR LOADED STEADY STATE TEST*

CONTROLLED VEHICLES

	IDLE		LOW CRUISE		HIGH CRUISE	
	HC	CO	HC	CO	HC	CO
I*	290	3.0	240	2.5	220	2.0
II*	350	4.0	300	3.0	300	2.5
III*	400	5.0	350	3.25	350	2.75
IV*	500	6.0	400	3.75	400	3.25
V*	600	7.0	450	4.25	450	3.75
VI	700	8.0	500	4.75	500	4.25

UNCONTROLLED VEHICLES

	IDLE		LOW CRUISE		HIGH CRUISE	
	HC	CO	HC	CO	HC	CO
I*	700	5.5	450	4.0	450	3.0
II*	800	7.0	550	4.5	550	3.5
III*	900	7.5	600	5.0	600	4.0
IV*	1000	8.0	700	5.25	700	4.25
V*	1200	9.0	900	5.5	900	4.5
VI*	1300	9.5	1000	6.0	1000	5.0
VII	1500	11.0	1200	7.0	1200	6.0

* Suggested Clayton **KEY MODE** rejection levels

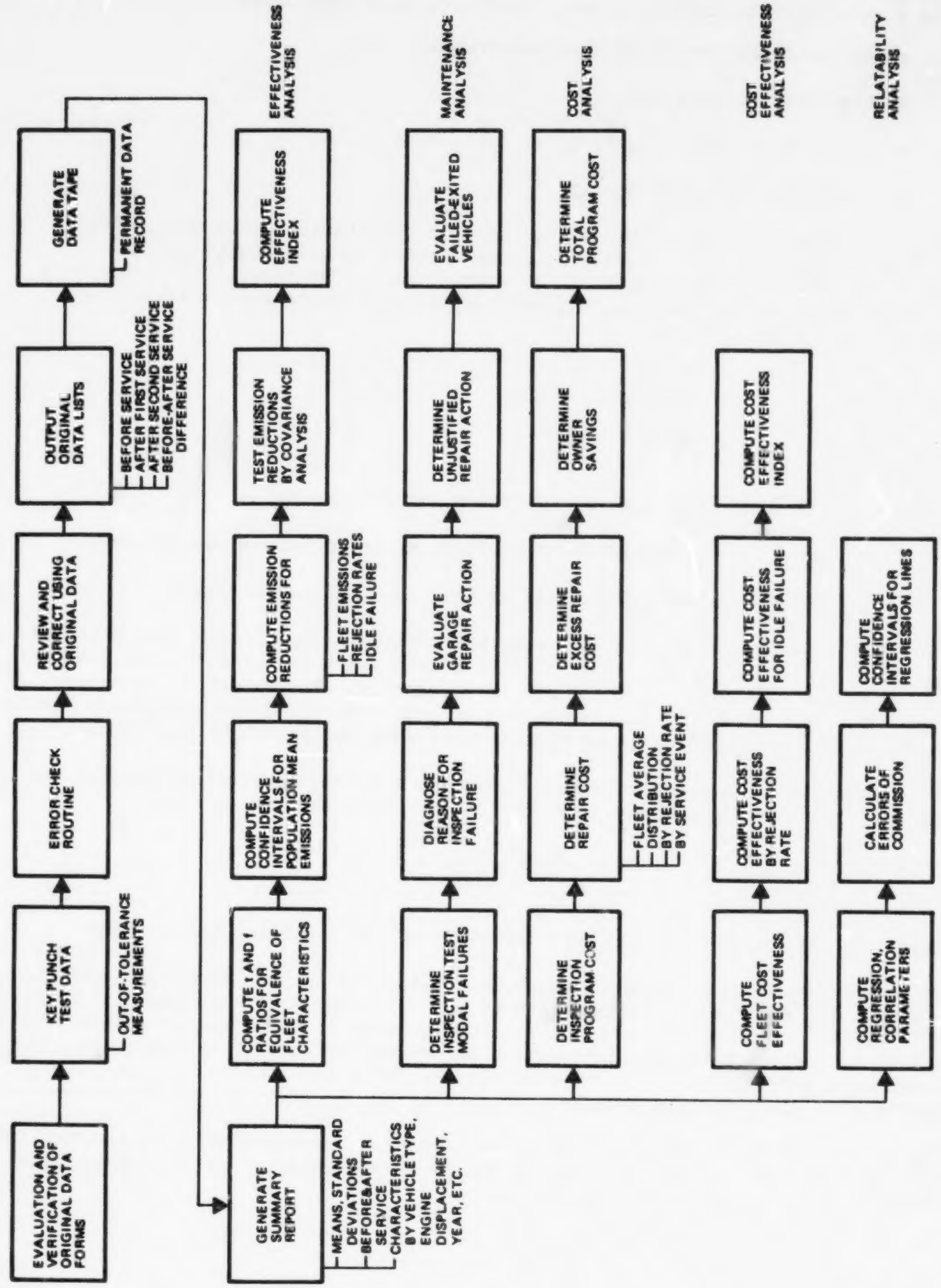

EVALUATION AND VERIFICATION OF ORIGINAL DATA FORMS
KEY PUNCH TEST DATA
OUT-OF-TOLERANCE MEASUREMENTS
ERROR CHECK ROUTINE
REVIEW AND CORRECT USING ORIGINAL DATA
OUTPUT ORIGINAL DATA LISTS
BEFORE SERVICE
AFTER FIRST SERVICE
AFTER SECOND SERVICE
BEFORE-AFTER SERVICE DIFFERENCE
GENERATE DATA TAPE
PERMANENT DATA RECORD
GENERATE SUMMARY REPORT
MEANS, STANDARD DEVIATIONS
BEFORE&AFTER SERVICE
CHARACTERISTICS BY VEHICLE TYPE, ENGINE DISPLACEMENT, YEAR, ETC.
COMPUTE t AND f RATIOS FOR EQUIVALENCE OF FLEET CHARACTERISTICS
COMPUTE CONFIDENCE INTERVALS FOR POPULATION MEAN EMISSIONS
COMPUTE EMISSION REDUCTIONS FOR
FLEET EMISSIONS
REJECTION RATES
IDLE FAILURE
TEST EMISSION REDUCTIONS BY COVARIANCE ANALYSIS
COMPUTE EFFECTIVENESS INDEX
EFFECTIVENESS ANALYSIS
DETERMINE INSPECTION TEST MODAL FAILURES
DIAGNOSE REASON FOR INSPECTION FAILURE
EVALUATE GARAGE REPAIR ACTION
DETERMINE UNJUSTIFIED REPAIR ACTION
EVALUATE FAILED-EXITED VEHICLES
MAINTENANCE ANALYSIS
DETERMINE INSPECTION PROGRAM COST
DETERMINE REPAIR COST
FLEET AVERAGE
DISTRIBUTION
BY REJECTION RATE
BY SERVICE EVENT
DETERMINE EXCESS REPAIR COST
DETERMINE OWNER SAVINGS
DETERMINE TOTAL PROGRAM COST
COST ANALYSIS
COMPUTE FLEET COST EFFECTIVENESS
COMPUTE COST EFFECTIVENESS BY REJECTION RATE
COMPUTE COST EFFECTIVENESS FOR IDLE FAILURE
COMPUTE COST EFFECTIVENESS INDEX
COST EFFECTIVENESS ANALYSIS
COMPUTE REGRESSION, CORRELATION PARAMETERS
CALCULATE ERRORS OF COMMISSION
COMPUTE CONFIDENCE INTERVALS FOR REGRESSION LINES
RELATABILITY ANALYSIS

Figure 2-3. Data Analysis Flow Chart

Averages were calculated for before service, after first service, and after second service. The following basic subfleets were considered:

- All vehicles (serviced plus unserviced)
- Serviced vehicles only
- Controlled vehicles only
- Uncontrolled vehicles only

The t-test and F-test were applied to the 1975 CVS emission data to establish if test fleets were statistically equivalent prior to maintenance and if the reductions achieved were statistically significant. The t-test for equivalence of sample means was applicable to groups of unequal sample size and variance and had the following form:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where: $\bar{x}_1$ and $\bar{x}_2$ are the mean of the first and second sample

s_1 and s_2 are the standard deviations of the first and second sample

n_1 and n_2 are the sample size of the first and second sample

The t-test determines whether the means are statistically identical or not, taking into consideration the number of data points and their distribution. Associated with the t-test is a probability of occurrance. The t-test analyses performed for this study can be interpreted to mean that population means are statistically equal at a 95% level of significance when the t-test is satisfied.

The F-test for equivalence of sample variances (standard deviation squared) was also performed on the various test fleets. The test statistics are:

$$F = \frac{s_1^2}{s_2^2}$$

where s_1 and s_2 are the standard deviation of the first and second sample

The F-test determines whether the sample variance or scatter about the mean is equivalent. The F-test can establish if the test samples are composed of vehicles with widely different emission characteristics even if the means are statistically equal. The F-test is also interpreted as the equivalence of variances at a 95% significance level if the F-test is satisfied. The F-test implicitly considers sample size since that is involved in calculating the two standard deviations.

The t-test and F-test were applied to all vehicles, serviced vehicles, controlled vehicles and uncontrolled vehicles to establish equivalences of all three pollutants in terms of the following groups:

- Idle and Loaded Steady State
- California and Michigan
- Phase I and Phase II

Demonstrating equivalence of Idle and L.S.S. fleets prior to maintenance provides assurance that sample sizes were sufficiently large so that representative samples were selected. The determination of whether one regime was statistically superior to the other was based on the analysis of covariance which is discussed in paragraph 2.3.3. The analysis of covariance is valid even if the t-test and F-test are not satisfied.

Demonstrating that the emission characteristics are similar in California and Michigan and during Phase I and Phase II does not affect the evaluation of Idle and L.S.S. emission reductions. The information, however, is useful in interpreting different emission reductions or cost results.

2.3.3 Effectiveness Analysis

The effectiveness of the Idle and L.S.S. regimes was defined by the emission reductions achieved. In addition to the emission reductions, statistical tests were performed to ensure that the Idle and L.S.S. test fleets were statistically equivalent, that statistically significant reductions were achieved, that one regime was more effective than the other and to predict expected statewide emission reductions.

2.3.3.1 Fleet Emission Reductions - The Effectiveness Analysis began with calculations of the emission reductions achieved by maintenance. Emission reductions were determined for the following four test fleets at an inspection test failure rate of approximately 30%:

- All vehicles
- Serviced vehicles only
- Controlled vehicles
- Uncontrolled vehicles

These emission reductions were determined for first service data and second service data in terms of percent reductions and gram per mile reductions. The emission reductions were tested in two ways: (1) t-test of mean emissions before and after maintenance, and (2) analysis of covariance of emission reductions.

The t-test was utilized to establish if a statistically significant difference in emission levels was achieved by maintenance. The t-test utilized was the same as previously discussed in paragraph 2.3.2. The F-test was not applied in this case since the emission reduction is expressed in terms of the change in mean value. Maintenance actions could, however, alter (reduce) the sample variance of emission even though the mean values before and after maintenance were statistically identical. This change would be manifested in small and statistically insignificant emission reductions.

Since both Idle and L.S.S. PVIM could create significant emission reductions, a more sensitive tool was required to select the regime which provided the greatest emission reduction. This tool was the analysis of covariance. The analysis of covariance is useful in establishing if several different treatments result in statistically equivalent effects, taking into consideration differences in initial conditions. For analysis, there were two treatments, Idle and L.S.S. PVIM, and the effect is the resulting emission reduction for each pollutant. The covariance statistic is tested by the following F ratio assuming completely randomized design (reference 6):

$$F = \frac{SS^{1}_{YT} - SS^{1}_{YE} / (r - 1)}{SS^{1}_{YE} / (N - r - 1)}$$

where:

F = The calculated F-ratio is compared to a tabulated F-value to determine if Idle and L.S.S. result in the same effect (reduction)

SS^{1}_{YE} = Sum of squares of after service within group deviations (SS_{YE}) minus the quantity: Sum of products of before and after service within group deviation (SP_E) divided by the sum of squares of before service within-group deviation (SS_{XE}). Within group deviation is calculated using the separate Idle mean values and L.S.S. mean values

SS^{1}_{YT} = Sum of square of after service total deviation (SS_{YT}) minus the quantity: Sum of products of before and after services total deviations (SP_T) divided by the sum of squares of before service total deviation (SS_{XT}). Total deviation is calculated using the combined Idle and L.S.S. mean values

N-r-1 = The degrees of freedom within groups where r is the number of treatments, i.e., Idle and L.S.S.; and N is the total number of vehicles in both groups

r-1 = The degree of freedom among groups

The analysis of covariance, therefore, establishes if there is statistically significant difference in the effects of the treatments, i.e., emission reductions achieved by Idle and L.S.S. The level of significance desired for the test determines the reference value of F which is obtained from statistical tables for the given degrees of freedom and significance level. All analysis of covariance tests were performed at the 95% level of significance.

If the F-ratio calculated from the covariance analysis was less than the corresponding reference F-value, then Idle and L.S.S. were equally effective in reducing emissions. If the calculated F-ratio was greater than the reference F-value, then the Idle and L.S.S. were not equally effective. Scheffer

(S-method) was used to establish which regime was greater in effect, i.e., emission reduction. The appropriate statistic is given below and is discussed in Guenther's, The Analysis of Variance (reference 6).

$$L = \sum_{j=1}^{2} C_j \bar{y}_{.j} - \frac{SP_E}{SS_{xE}} \sum_{j=1}^{2} C_j \bar{x}_{.j}$$

$$\sigma_L^2 = \frac{SS_{YE}^1}{N-r-1} \left[\sum_{j=1}^{2} \frac{C_j^2}{n_j} + \frac{\left(\sum_{j=1}^{2} C_j \bar{x}_{.j} \right)^2}{SS_{YE}} \right]$$

$$S^2 = (r-1)\ F_{1-\alpha;\ r-1,\ N-r-1}$$

where:

$j = 1$ is Idle
$ = 2$ is L.S.S.

$C_1 = 1$

$C_2 = -1$

$\bar{X}_{.j}$ = before service mean of test regime j

$\bar{Y}_{.j}$ = after service mean of test regime j

n_j = number of vehicles in test regime j

SP_E, SS_{XE}, SS_{YE}^1 = defined for covariance analysis

N-r-1, r-1 = defined for coveriance analysis

If the calculated value of $\frac{L^2}{\sigma_L^2} > S^2$, the two test regimes in comparison provide statistically different emission reductions. Then the Idle is superior to L.S.S. if L is negative and L.S.S. is superior to Idle if L is positive.

2.3.3.2 Emission Reductions as a Function of Inspection Test Rejection Rate - The effectiveness analysis included assessment of emission reductions at rejection rates from 10% to 50% of the population. The purpose of this analysis was to show how much incremental emission reduction was achieved as larger and larger percentages of vehicles were failed and sent for maintenance. The expectation, of course, is that the greatest increment of reduction is achieved by servicing the worst 10% of the vehicles, with service to each subsequent 10% group providing progressively less emission reduction.

This analysis was performed by using the three Loaded Steady State (L.S.S.) modes shown in Table 2-6. The six L.S.S. limits were applied to the L.S.S. vehicle fleets for each rejection rate. The HC and CO idle limits of the L.S.S. test were applied to the Idle vehicle fleets. A vehicle was rejected if any pollutant in any applicable mode exceeded the indicated values.

The values in Table 2-6, marked with an asterisk (*) are Clayton Manufacturing Company recommended KEY MODE limits. They were intended to reject from 30% to 60% of the controlled vehicles and 20% to 70% of the uncontrolled vehicles. In this program, these limits tended to reject more vehicles than desired. Therefore, the rejection limits identified as level VI for controlled vehicles and level VII for uncontrolled vehicles were established by OLI to provide a rejection rate between 10% and 20% of inspected vehicles.

2.3.3.3. Emission Reductions Achieved by Correcting Idle Only Failure - If most of the vehicles require idle system maintenance only, then the emission reductions achieved by Idle and L.S.S. might be equal. The additional information available to L.S.S. garages, however, might enable them to provide the emission reductions at less cost than the Idle garages. Therefore, in order to test this hypothesis, the Idle and L.S.S. test fleets were examined to select only those vehicles which had failed the emission test only at idle. The L.S.S. vehicles with power mode failures were excluded. The Idle Mode vehicles which would have failed any of L.S.S. cruise modes, had they been an L.S.S. vehicle, were also excluded. The average emission reductions of HC, CO and NO_x were determined for these failed vehicles. The emission reductions were then available for use in the cost effective analysis as described in paragraph 2.3.6.

2.3.3.4. Effectiveness Index - Effectiveness of the Idle and L.S.S. test regimes was measured using an index which combines the effects of exhaust emission reduction, vehicle population, model-year distribution, average vehicle miles driven, and anticipated inspection failure rates. This effectiveness index was applied to the 1975 CVS test data generated from the 600 vehicles involved in this program. The resulting effectiveness indices were then used to evaluate total program effectiveness of Idle and L.S.S. The effective index is presented below:

$$\mathrm{MOE} = \sum_{n=1}^{3} C \cdot P \cdot K_n \cdot W_n(Y) \cdot D(Y) \cdot M(Y)$$

where:

MOE = measure of effectiveness, in tons of pollutants per year

P = total vehicle population

D (Y) = vehicle distribution by vehicle age

M (Y) = vehicle average miles driven per year, by vehicle age

K_n = proportional pollutant weighing factor (n=1,2,3)

$W_n(Y)$ = magnitude of change for each pollutant in grams/mile by vehicle age as a function of model year

Y = number of model years encompassed (15 years)

C = conversion factor, grams to tons (1.1×10^6)

n = index of pollutants, 1=HC, 2=CO, 3=NO_x

Each of the above parameters is described in the following paragraphs.

Vehicle Population, P

The factor P represents the total beginning population of vehicles for which the MOE is being computed. In this study, MOE's are computed based on 1971 California and Michigan populations, which were 10,000,000 vehicles and 5,500,000 vehicles respectively.

Vehicle Distribution by Model Year, D(Y)

The vehicle distribution by model-year are taken from Table 2-1 shown on page 2-5 for both California and Michigan. They are assumed to be constant and equivalent throughout the program year.

Vehicle Average Miles Driven, M(Y)

The amount of emissions prevented from entering the atmosphere is dependent on the age of the vehicle in the population and the associated vehicle miles driven per year. Based on data generated during the California Air Resources Board Study, Table 2-7 shows the average miles driven annually for vehicle age category (reference 1). The data in this table were derived only for vehicles registered in California since this study did not provide for a survey of typical driving profiles in Michigan. The data were, however, used for the Michigan analysis.

Weighting of Emission Pollutants, K_n

Overall program effectiveness should be related to total air pollution reduction. Since, however, considerable technical discussion centers on the relative importance of the pollutants, simple summation of mass emissions reduction may not be applicable to all regions. Therefore, this report presents each pollutant separately as well as the two feasible pollutant weighting methods shown below:

algebraic sum

$$\Delta HC + \Delta CO + \Delta NO_x$$

weighted algebraic sum

$$.6\,(\Delta HC) + .1\,(\Delta CO) + .3\Delta NO_x$$

The algebraic sum is the most straightforward scheme. This simply creates an overall effectiveness index which is directly proportional to the cumulative increases or decreases exhibited by the three pollutants. The equal weighting

Table 2-7

AVERAGE MILES DRIVEN ANNUALLY

Vehicle Age in Years	Average Miles Driven Annually
Under 1	13,200
1-2	12,000
2-3	11,000
3-4	9,600
4-5	9,400
5-6	8,700
6-7	8,600
7-8	8,100
8-9	7,300
9-10	7,000
10-11	5,700
11-12	4,900
12-13	4,300
13-14	4,300
14-15	4,300
15 and over	4,300

philosophy emphasizes any reductions in CO, however, since this pollutant constitutues the greatest mass of emissions and emission reductions. The equal weighting method is also presented in a normalized form to enable direct comparison with the weighted sum.

The weighted sum was selected arbitrarily by Olson/Northrop with concurrence from the EPA Project Officer. The weighting factor is derived from the 1970-1971 Federal emission standards and provides a method of weighting each pollutant inversely proportional to its emission standards. In other words, the weighting implies that a ton reduction of HC or NO_x is much more important than a ton reduction of CO. The calculation procedure is shown in Table 2-8. It may be summarized as follows:

- determine total permitted emissions by summing emission standards
- determine proportion of total emissions represented by each pollutant
- calculate reciprocal (inverse) of proportion
- sum the inverse proportions
- divide each inverse proportion by the sum of the inverse proportions to obtain normalized factors

Emission Changes, W_n (Y), Due to Maintenance

This factor accounts for changes in emission resulting from maintenance actions. This factor is developed for each pollutant, each model year group and each test regime. It represents reductions (or increases) in 1975 CVS emissions averaged over both serviced and unserviced vehicles.

Table 2-8
CALCULATION OF POLLUTANT WEIGHTING FACTORS

Identify Standard	
HC	2.2 grams per mile
CO	23.0 grams per mile
NO*	4.0 grams per mile
Sum Permitted Emissions	
T = HC + CO + NO	29.2 grams per mile
Calculate Proportion of Total	
$\frac{HC}{T}$	0.075
$\frac{CO}{T}$	0.788
$\frac{NO}{T}$	0.137
Calculate Inverse Proportions	
$\frac{T}{HC} = hc$	13.3
$\frac{T}{HC} = co$	1.3
$\frac{T}{NO} = no$	7.3
Sum Inverse Proportions	
$\Sigma = hc + co + no$	21.9
Calculate Normalized Inverse Proportions	
$\frac{hc}{\Sigma}$	0.61
$\frac{co}{\Sigma}$	0.06
$\frac{no}{\Sigma}$	0.33
Round Off Weighting Factors	
K_{hc}	0.6
K_{co}	0.1
K_{no}	0.3

*Assumed NO_x emission levels of 4 grams per mile.

2.3.4 Maintenance Analysis

After all cars were repaired and retested, an evaluation was made to determine whether the garages had properly identified malfunctioning systems and performed the minimum work to meet emission limits; or whether they had performed unnecessary, excessive or ineffective repair actions This section outlines the methodology for evaluating service center repair action, excessive or unjustified repair service, failed and exited vehicles, and an OLI project staff diagnosis of the failed vehicles. The maintenance analysis was performed on Phase I and Phase II data separately for the vehicles failing the 30% rejection level.

2.3.4.1 Modal Failure Analysis - The modal failure analysis provided a means of identifying the frequency of failures for different modes and pollutants. The modal failure characteristics of the Idle and L.S.S. vehicles were established from the respective emission inspection test data. This analysis is presented in graphical form showing the percent of the failing vehicles which failed for HC and/or CO at idle for the Idle vehicles; and HC and/or CO in combinations of idle and power modes for the L.S.S. vehicles. Controlled vehicles were treated separately from uncontrolled vehicles. The reader is reminded that the rejection limits used here were different than those actually used to fail vehicles in the test program. The analysis provided a means of evaluating the repairs required to correct the emission failures.

2.3.4.2 Diagnosis of Failed Vehicles - Every vehicle which failed its first emission inspection test was diagnosed to determine the repair action which would have resulted in the vehicle passing its emission test. This analysis was conducted after the conclusion of program testing independently of the actual diagnosis and repair actions performed on the vehicles. All of the emission data available from the test program (Idle, L.S.S., and 7-Mode) was used for this diagnosis. This analysis was performed on Phase I and Phase II separately and for uncontrolled and controlled vehicles separately.

This analysis identified the number of failed vehicles in each fleet which required the following general types of repair work:

- idle adjustment only (mixture, speed, timing)
- ignition repair (replacement of plugs, points, condensor, distributor advance mechanisms, wiring and associated adjustments)
- carburetion repair (rebuild or replace the carburetor, PCV service)
- ignition plus carburetion repair
- major mechanical repair (repair or replacement of valves, and/or rings)

Since only emission inspection test data were available for this analysis, more detailed diagnosis was not possible. The results of this analysis are presented in Section 3.4.

2.3.4.3 Service Center Repair Action - An analysis was conducted to determine whether the service center diagnosis and repair actions had reflected correct repair action. Figure 2-4 shows the inspection test and repair action sequence. If the vehicle passed the inspection tests after service, the repair action was evaluated as being correctly repaired. If the vehicle failed the inspection test after service it was diagnosed by OLI and received a second repair service. Vehicles which required major mechanical repair (valve grinds and overhauls) were exited as failing vehicles. Following the second service and inspection test, the vehicles were passed or failed and exited from the system in a similar manner to the first service and inspection test without further diagnosis or repair.

If the vehicle had passed the inspection tests after service, it was judged as having a correct diagnosis as well as correct repair, although it may also have received some unjustified (excessive) repair service. If it failed, the vehicle was judged as having incorrect repair service. No positive engineering judgments were made on incorrect diagnosis conducted by the service center or by the OLI mechanics. The second emission inspection failure could have been due to either incorrect diagnosis of a subtle malfunction or an improperly executed repair.

Idle garages were to conduct minor tune-up related adjustments such as timing, dwell, and idle mixture and speed adjustments and minor repair items such as PCV, exhaust control systems, and filter services. If this step did not correct the high emission levels, the repair center was directed to repair and/or service the ignition or carburetion systems in accordance with the sequence of steps shown in Table 2-9.

Table 2-9. SUGGESTED REPAIR ACTION FOR IDLE AND LOADED STEADY STATE INSPECTION TESTS*

Emission Data*	Step	Suggested Repair Action
CO High	1	Minor tune-up adjustment and repair
HC Normal	2	Carburetor service (repair or replace)
CO Normal	1	Minor tune-up adjustment and repair
HC High	2	Electrical tune-up
CO High	1	Minor tune-up adjustment and repair
HC High	2	Electrical and/or carburetor service
CO Low	1	Minor tune-up adjustment and repair
HC High	2	Carburetor service (repair or replace)

* Idle emission data only supplied to Idle inspection service centers. Idle, low cruise, and high cruise emission data supplied to L.S.S. inspection centers.

At the beginning of Phase I, L.S.S. garages were instructed to follow Table 2-9 in the same manner as the Idle garages; except that the KEY MODE Charts and booklet shown in Appendix A-2 were to be used in establishing the most

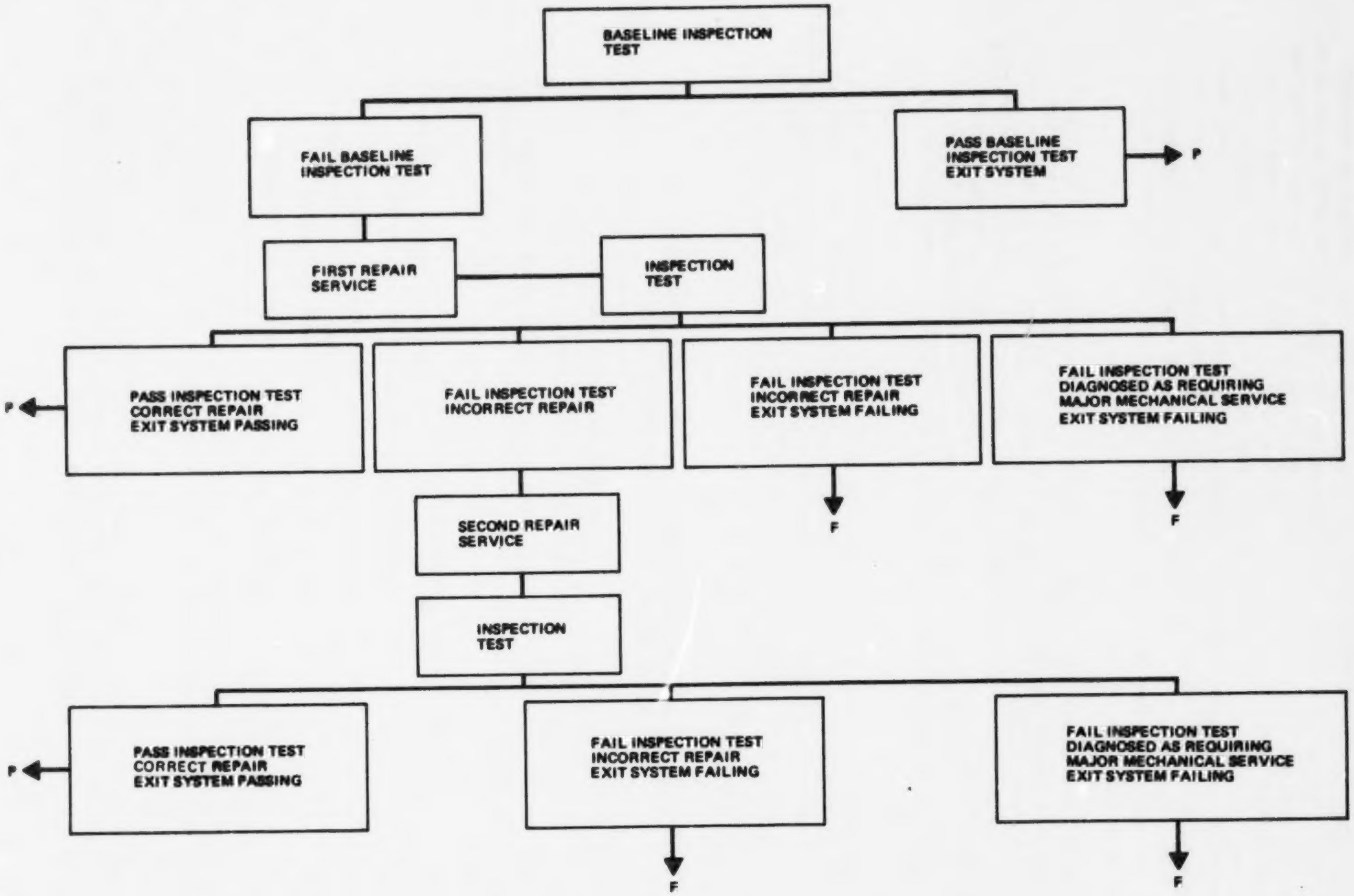

BASELINE INSPECTION TEST
FAIL BASELINE INSPECTION TEST
PASS BASELINE INSPECTION TEST EXIT SYSTEM
P
FIRST REPAIR SERVICE
INSPECTION TEST
PASS INSPECTION TEST CORRECT REPAIR EXIT SYSTEM PASSING
P
FAIL INSPECTION TEST INCORRECT REPAIR
FAIL INSPECTION TEST INCORRECT REPAIR EXIT SYSTEM FAILING
F
FAIL INSPECTION TEST DIAGNOSED AS REQUIRING MAJOR MECHANICAL SERVICE EXIT SYSTEM FAILING
F
SECOND REPAIR SERVICE
INSPECTION TEST
PASS INSPECTION TEST CORRECT REPAIR EXIT SYSTEM PASSING
P
FAIL INSPECTION TEST INCORRECT REPAIR EXIT SYSTEM FAILING
F
FAIL INSPECTION TEST DIAGNOSED AS REQUIRING MAJOR MECHANICAL SERVICE EXIT SYSTEM FAILING
F

Figure 2-4. Service Center Repair Analysis

likely cause of emission failure. The L.S.S. procedure would, therefore, tend to concentrate diagnostic and repair effort on those items which had a high probability of failure.

During Phase II, the L.S.S. garages were specifically instructed to follow only the KEY MODE Truth Charts and booklet. In most instances of modal failures which included a power mode failure, the vehicles were serviced by step 2 in Table 2-9 with the minor adjustments being performed after completing the main repair effort. For vehicles with Idle failures only, the Truth Charts direct the L.S.S. garages to follow the same repair sequence as shown in Table 2-9.

The service center repair action analysis also summarized the repair actions actually conducted by the garages. Repair invoices and the data sheets provided to the garages were used to separate costs into the following five categories:

- minor adjustments (adjustments to the carburetor and distributor such as idle mixture, rpm, timing, and dwell)
- minor repair (replacement of parts such as filters, PCV valve, heat riser, vacuum lines, gaskets, hoses, etc.)
- ignition repairs (replacement of plugs, points, condenser, distributor advance mechanisms, wiring, and the associated adjustments)
- carburetion repair (rebuild or replace the carburetor)
- major mechanical repair (repair or replacement of items such as rings and valves)

The service center repair action analysis was presented and discussed for first service. Data is available in paragraph 3.4 to derive the information for second service. The data is presented separately for Phase I and Phase II and for controlled and uncontrolled vehicles separately.

2.3.4.4 Unjustified Repair Action - An evaluation of unjustified repair action was conducted by examining the inspection test results and the repair invoices. Generally, if carburetor related excess emission (high CO and moderately high HC, less than 1500 ppm) were evident from the inspection test data, minor carburetion and ignition adjustments were justified. However, if ignition misfire (hydrocarbons in excess of 1500 ppm) was clearly not indicated by the inspection test, replacement of ignition parts was judged to be an unjustified repair action. If the analysis showed that carburetor idle adjustment should have corrected high CO emissions and the carburetor had been overhauled or replaced, the repair action was evaluated as unjustified. Tables 2-10 and 2-11 present the criteria for judging excessive repairs for Idle and L.S.S. respectively.

From the results of the analysis, repairs which appeared to be ineffective, excessive and unjustified, were identified and tabulated. The costs associated with the excess repairs were deducted resulting in revised cost and cost effectiveness indices. The possible impact of inadequate training and experience are discussed in Paragraph 3.4 along with a revised maintenance procedure expected to reduce unnecessary repairs.

Table 2-10
PROPER REPAIR ACTION, IDLE MODE

Emission Data	Allowable Repair Action
CO High, HC Normal	Adjustment, minor item replacement, carburetor repair, emission control repair
HC High, CO Normal	Adjustment, electrical tune-up, minor item replacement
CO High, HC High	Adjustment, electrical tune-up, carburetor repair or replacement

Table 2-11
PROPER REPAIR ACTION, LOADED STEADY STATE

	Emission Data	Allowable Repair Action
Idle	CO High, HC Normal	Adjustment, minor item replacement, emission control repair
	HC High, CO Normal	Adjustment, electrical tune-up, minor item replacement
	CO High, HC High	Adjustment, electrical tune-up, carburetor repair
Lo & Hi Cruise	CO High, HC Normal	Adjustment, minor item replacement, carburetor repair or replace
	HC High, CO Normal	Adjustment, electrical tune-up, minor item replacement
	CO High, HC High	Adjustment, electrical tune-up, carburetor repair or replace

2.3.4.5 Analysis of Exited Failing Vehicles - Several vehicles were exited from the program still failing their inspection test after maintenance (see Figure 2-4). In some instances the vehicles had received an incorrect service action and quite often failed because of improper minor adjustments (such as idle mixture). In other cases major mechanical repair actions such as valve regrind and engine overhaul were diagnosed, and the vehicle was exited as failing due to the program restrictions discussed in Section 2.2.3. Section 3.4 presents a summary of the failed and exited vehicles which includes the estimated costs of the major mechanical services had they been performed.

2.3.5 Program Cost Analysis

This paragraph describes the analysis of the costs of implementing and operating an Idle or L.S.S. PVIM program in California and Michigan. The approach determined both annual inspection and repair costs on a per-vehicle basis in each state. Total costs were then determined by multiplying the derived per-vehicle cost by the respective state vehicle populations. Allocating program costs to the individual vehicle was useful for evaluating: 1) the recovery of inspection program costs through the inspection fee and 2) the cost of the program to the vehicle owner and the resulting public acceptability.

The two major categories of cost (inspection and repair) associated with implementation of a PVIM program were derived by different means. Inspection program costs, described in paragraph 2.3.5.1, were based on those derived by purely analytical means as part of a previous Northrop/Olson study performed for the California Air Resources Board (Reference 1). Costs resulting from repair actions were derived from actual repair cost data on the cars tested during the Short Cycle Project in California and Michigan as described in paragraph 2.3.5.2. Total program costs, the combination of inspection and maintenance costs, are described in paragraph 2.3.5.3.

2.3.5.1 Inspection Cost Analysis - Inspection costs were defined as the costs associated with establishing and operating a network of vehicle inspection centers sufficient for a practical program of mandatory annual emissions tests for all light duty vehicles. The two alternative inspection programs (Idle and L.S.S.) under evaluation involved an extremely large number of fixed and variable cost items. To facilitate cost analysis of the alternatives, a linear life-cycle cost (LSS) model was developed during the previous California ARB study (Reference 1). This LCC model identified and quantified the various program cost categories involved for each of four program alternatives including Idle and KEY MODE. The LCC model assured that the required resources were systematically considered, assisted in the analytical process, facilitated data acquisition and mathematical computation, and identified areas of critical resource requirements.

The California ARB inspection program cost analysis considered implementation and operation of a state or single contractor operated inspection station network throughout California. The useful lifetime of the inspection station network was assumed to be 10 years with 5 year useful life of instrumentation. This network was sized to accommodate the expected California vehicle population assuming annual growth and accounting for the regional distribution of vehicles.

The LCC model's resulting inspection cost for Idle and KEY MODE was determined for the first year of the program. The estimated costs occurring in 1973 were taken to be the average cost applicable to the Short Cycle Project analysis. This total cost was then divided by the projected number of vehicles in 1973 to arrive at an average cost per vehicle for: 1) inspection system implementation and investment costs and 2) inspection system operating costs. These per-vehicle costs were then used to estimate the cost of an inspection program in Michigan.

The LCC model was composed of three major submodels corresponding to the three major program phases: 1) research and development, 2) acquisition and investment, and 3) operation and maintenance. The model had the form indicated below:

$$LCC = \sum_{n=1}^{Y} \left(C_{RD} + C_{INV} + Ke_n C_{OP_n} \right)$$

where:

LCC = total program cost for expected duration

n = index of years in life-cycle duration

Y = expected number of years in life cycle

C_{RD} = program research and development expenditures, in dollars

C_{INV} = facility acquisition and investment expenditures, in dollars

Ke_n = escalation factor applied for year n

C_{OP} = operation and maintenance expenditures, in dollars

In the following paragraphs the major categories are further defined:

Program Research and Development Costs (C_{RD}) - The research and development category included all costs necessary to conceive, design, develop, and document a total program capable of satisfying the identified goals and objectives. For each of the program alternatives evaluated, this cost category identified and quantified the expenditures necessary to finalize the concept to the point of implementation. Specific equipment, personnel, facilities, support management procedures, and other considerations were costed to assure complete coverage of resources. Most, if not all, of the hardware needed to implement the alternative programs was off-the-shelf equipment and, therefore, no research and development costs were required for that purpose. Potential additions or modifications to existing procedures or equipment were also included under this category to assure adequate funds for planning prior to selection and implementation.

Facility Acquisition and Investment Costs (C_{INV}) - The acquisition and investment category included all the resources and costs incurred in the process of initial program implementation. The resource elements included site acquisition, facilities, instrumentation, and manpower. Associated functional elements included facility certification, and personnel indoctrination and training. This category included expenditures that were non-R&D or nonrecurring.

Operation and Maintenance Costs (C_{OP}) - Operation and maintenance cost elements included personnel salaries, wages, and benefits. On-going personnel training and upgrading programs were included to assure continuing satisfactory operation. The maintenance of inspection equipment, purchase of tools and supplies, and program administration costs were also included.

2.3.5.2 Maintenance Cost Analysis - The owner of a vehicle that fails to satisfy the inspection test requirements will incur repair costs to bring the vehicle's emission levels within the established standard. Offsetting this cost would be any savings resulting from these repair actions. The principle savings would probably be decreased fuel consumption due to the greater engine efficiency achieved through PVIM. Fuel savings are discussed below. The routine maintenance which all vehicles require for good operation may be deferred by the owner for any vehicle which fails the inspection test and is serviced to achieve compliance. This savings is difficult to quantitize and would be applied equally to Idle and L. S. S. Therefore this savings will not be included in the Idle or L. S. S. cost analysis of the Short Cycle Project.

In order to establish maintenance costs, a record of garage repair charges was kept for all serviced vehicles in the test program. Costs were segregated according to program phase, test regime, and the five types of repair actions described in paragraph 2.3.4.3. Vehicles with major mechanical failures were exited without repair and the associated costs were estimated from prevailing charges for the type of repairs required. The maintenance costs were analyzed and presented for first service and second service, and included the average cost for each type of service action, the average cost per vehicle for the serviced fleet, and the average cost per vehicle for the total vehicle fleet. Cost analysis for the two phases are presented separately and in combination. As part of the maintenance action analysis, certain repair actions were identified as being excessive. In these cases, the garage had performed repair work in excess of that indicated by the inspection test results. Those costs which could be identified as excessive were deducted from the actual cost calculations resulting in revised costs per vehicle. Maintenance cost was determined as a function of inspection test rejection rate for the same vehicles included in the effectiveness analysis described in paragraph 2.3.3.2. Maintenance costs were determined for those Idle and L. S. S. vehicles which did not fail cruise modes as described in paragraph 2.3.3.3 (the analysis of Emission Reductions Achieved by Correcting Only Idle System Malfunctions).

Fuel savings were estimated on the basis of measurements made during the simulated 7-1/2 mile 1972 CVS dynamometer test runs on the dynamometer before and after repair. Annual fuel savings were calculated from measured fuel consumption W, based on 10,000 miles per year of driving and a price of 40¢ per gallon as shown below:

$$C_s = \Delta W \cdot M \cdot K \cdot C_g$$

where:

C_s = fuel savings in dollars per year

ΔW = change in fuel consumption (pounds of fuel per mile)

M = miles driven per year = 10,000 miles (estimate)

K = gallons per pound fuel; constant = $\frac{1}{6.2}$

C_g = cost of gasoline per gallon = \$0.40 (estimate)

These data show considerable inconsistencies, wherein fuel consumption does not always decrease with decreased emissions. It is believed that the resolution of the measurement technique was not great enough to accurately detect small changes in fuel consumption. Therefore, the maintenance cost analysis is presented without including these fuel savings.

2.3.5.3 Total Program Cost - The results of the inspection program cost analysis and maintenance program cost analysis were combined to give the total program cost of Idle and L.S.S. PVIM. Costs are presented in total dollars and per vehicle. The total program cost is presented for Phase I and Phase II separately. The total program cost is combined with the effectiveness analysis in the cost effectiveness analysis as described below.

2.3.6 Cost Effectiveness of Inspection and Maintenance

This section relates the effectiveness measures described in paragraph 2.3.3 for each inspection and maintenance regime (Idle and L.S.S.) with the cost analyses, described in paragraph 2.3.5, for each regime. The cost effectiveness analysis quantified in a single index the benefits obtained per unit cost. As such, the cost effectiveness was able to make a better selection between the two alternatives than just examining either cost or effectiveness alone.

The cost effectiveness analysis was presented in two formats: 1) fleet average cost effectiveness and 2) the cost effectiveness index. Fleet average cost effectiveness considered emission reductions and maintenance cost. The fleet cost effectiveness was presented for several inspection test failure rates and for those vehicles which failed only idle emission levels (the analysis of Effectiveness of Correcting Idle Only Failures). The fleet average cost effectiveness was presented using emission reductions and repair cost distributed over all repaired vehicles in terms of emission reductions per repair cost (gram per mile per dollar).

The cost effectiveness index combined the results of the effectiveness index and total program cost for California and Michigan. The cost effectiveness index combined all three pollutants according to the pollutant weighting factors of the effectiveness index. The cost effectiveness index permitted selection of the regime which was most cost effective at approximately a 30% failure rate. Both actual repair costs and corrected repair costs (less excess repairs) were presented. The cost effectiveness analysis was presented in terms of annual emission reduction per net inspection and maintenance cost (tons per year per dollar).

2.3.7 Relatability Analysis

This subsection describes the procedures used to evaluate results of various short emission inspection tests against those obtained by using both the 1972 and 1975 CVS tests. The concept of relatability may be understood by realizing the statistics developed in this paragraph deal with measuring how well any given short test might do in passing and failing the same vehicles which would have passed and failed the 1975 CVS test. Emission data obtained from the short tests were correlated against measurements taken by the CVS procedure. Regression coefficients, correlation coefficients, estimate of errors, and confidence limits were computed for each short test with respect to the CVS tests. Analyses were also conducted to determine the impact of expected errors of commission caused by the Idle and L.S.S. tests.

2.3.7.1 Correlation and Regression Analysis - Mathematic relatability was defined by the regression coefficients. The regression coefficients described a line representing a best fit through the set of paired short test and CVS sample points. That is, given a short test measurement, the regression coefficients permit calculation of the most likely CVS measurement to be expected. A least squares linear regression equation of the form $y = a + bx$ was used. The CVS measurements, y, may be "predicted" given the short test measurements, x, and a knowledge that when x is zero, y will be equal to some constant "a". As x varies, y will vary by an amount proportional to b. Thus, the appropriate regression equation will enable prediction of an expected value of the CVS procedure emissions from a measured short test emission value.

For the multiple steady state speeds, such as KEY MODE, more than one independent variable was involved. A standard stepwise multiple linear regression computer program was used which generated an equation of the form:

$$y = a + b_1 x_1 + b_2 x_2 \ldots\ldots$$

The program selected the optimum regression equation, i.e., the equation which included as many steady state speeds (independent variables) as possible so that more reliable expected CVS values could be computed (predicted). At the same time, the program determined those speeds which did not significantly contribute to predicting accurate CVS values and did not include them. At every stage of the regression, the process examined the variables incorporated into the model in the previous stage. A variable which may have been the best single variable at an earlier stage may not now be significant due to the relationships between it and other variables inserted into the regression equation. The partial F criterion* for each variable in the regression at every stage of calculation was evaluated and compared with a preselected percentage point of the appropriate F distribution (90% significance level). Any variable whose contribution was no longer significant was removed from the model even if it had previously been incorporated.

The correlation coefficient, also known as the coefficient of multiple regression (MR), indicated how much of the variations in short test values were also present in the CVS procedure values. For example, if a correlation coefficient was computed at 0.8, this indicates that $(0.8)^2 \times 100\%$, or 64%, of the variations exhibited by the given short test measurements were explainable in terms of similar variations in the CVS measurements. When estimating the correlation coefficient for the total population, some allowance must be made to account for the random variations in vehicles. Therefore a 95% confidence band (Z), in percent of MR, was computed for each correlation coefficient. The correlation coefficient plus or minus Z percent of MR indicated quality of the prediction of the CVS value from the inspection test measurements.

An important qualifier of the regression equation was the confidence which may be placed in the coefficients of the equation. For example, if the intercept "a" was computed to be 2.7, the degree that "a" varied about its computed value because of the imperfect association between the variables should be known. The same type of information concerning the slope "b" of the regression equation was also desirable. For purposes of this study, it was considered satisfactory to know the ranges in which a and b will fall in at least 90 percent of the cases (90 percent confidence interval). The confidence intervals AL and BL presented in the Appendix represent the percentage variation above or below the estimated mean value for a and b, respectively.

---

*Partial F criterion: Utilizes the value of the partial F-ratio. If this value is less than the preselected F value, the variable will be rejected from the regression equation. For a more complete description of the Least Squares Method of curve fitting, the reader may refer to Statistical Analysis by Ya-Lun Chou, Holt, Rinehardt and Winston, New York, 1969, or other texts on statistical analysis.

Another qualifier computed for the regression equation was the standard error of the estimated equation, SE, the square root of S^2. SE is an unbiased estimator of the population standard deviation of regression and measures the variability between the individually computed predicted CVS values (using the regression equation) and associated actual CVS values.

In conducting the regression analysis for short emission test regimes, it was assumed that a linear relationship existed between the two variables. To perform the test for linearity of regression, the technique of analysis of variance was used. The F-ratio was calculated using the mean square error due to regression (MSR) and the SE of estimate. This parameter (F) was also tabulated in Appendix C containing regression equations. In this study, an F-ratio significance level of 0.95 was chosen. If the calculated value of F exceeds the critical value 3.92, then the hypothesis of non-linearity is rejected, that is, the variables exhibit a linear relationship. Confidence bands of the predicted CVS test values were calculated from the regression equations.

The confidence bands shown in Figure 2-5 are non-linear (hyperbolic) because the greater number of data points clustered about the mean allows assignment of a smaller band for a given confidence than at the ends of the distribution. The 90% confidence band is interpreted to mean that no more than 10% of the predicted (or actual) data points will fall beyond the 90% confidence band. Assuming that the data is normally distributed, equal chances exist that any one predicted CVS measurement will be either above or below the actual CVS value; or above the upper or below the lower confidence bands. Three pairs of confidence bands are shown: 1) the 90% confidence band of a single measurement, 2) the 90% confidence band of a fleet mean and 3) the 95% confidence band of a fleet mean.

The regression and correlation analysis was performed on combined Phase I and Phase II data for the vehicle fleets in California and Michigan separately and in combination.

2.3.7.2 Errors of Commission Analysis - An error of commission was defined as failing a vehicle and performing maintenance on the basis of a short emission inspection test when it actually would have passed an equivalent limit if tested by the 1972 or 1975 CVS procedure. Errors of commission are undesirable in that they subject a vehicle to unnecessary maintenance thereby resulting in minimal emission reductions. The following paragraphs describe the analytical approach used to evaluate commission errors at failure rates from 10% to 50% for the Idle and L.S.S. PVIM regimes.

The "predicted" CVS values were computed using the appropriate short emission inspection test vs CVS test regression equation. The vehicles were ranked by predicted CVS value in order from highest to lowest emitter and partitioned into decile groups, each representing 10% of the fleet, from the highest emitter down to the fiftieth percentile. The predicted CVS emission level corresponding to L-0.01 gram per mile was then selected as the rejection limit for that decile group where L was the predicted CVS emission level of the lowest emitter in that decile group. The numerical value of L-0.01 was then assigned as the equivalent actual CVS emissions, for the purpose of determining errors of commission.

For the vehicles with predicted CVS emissions greater than L-0.01, commission errors were those in which the actual CVS emission value was less than L-0.01

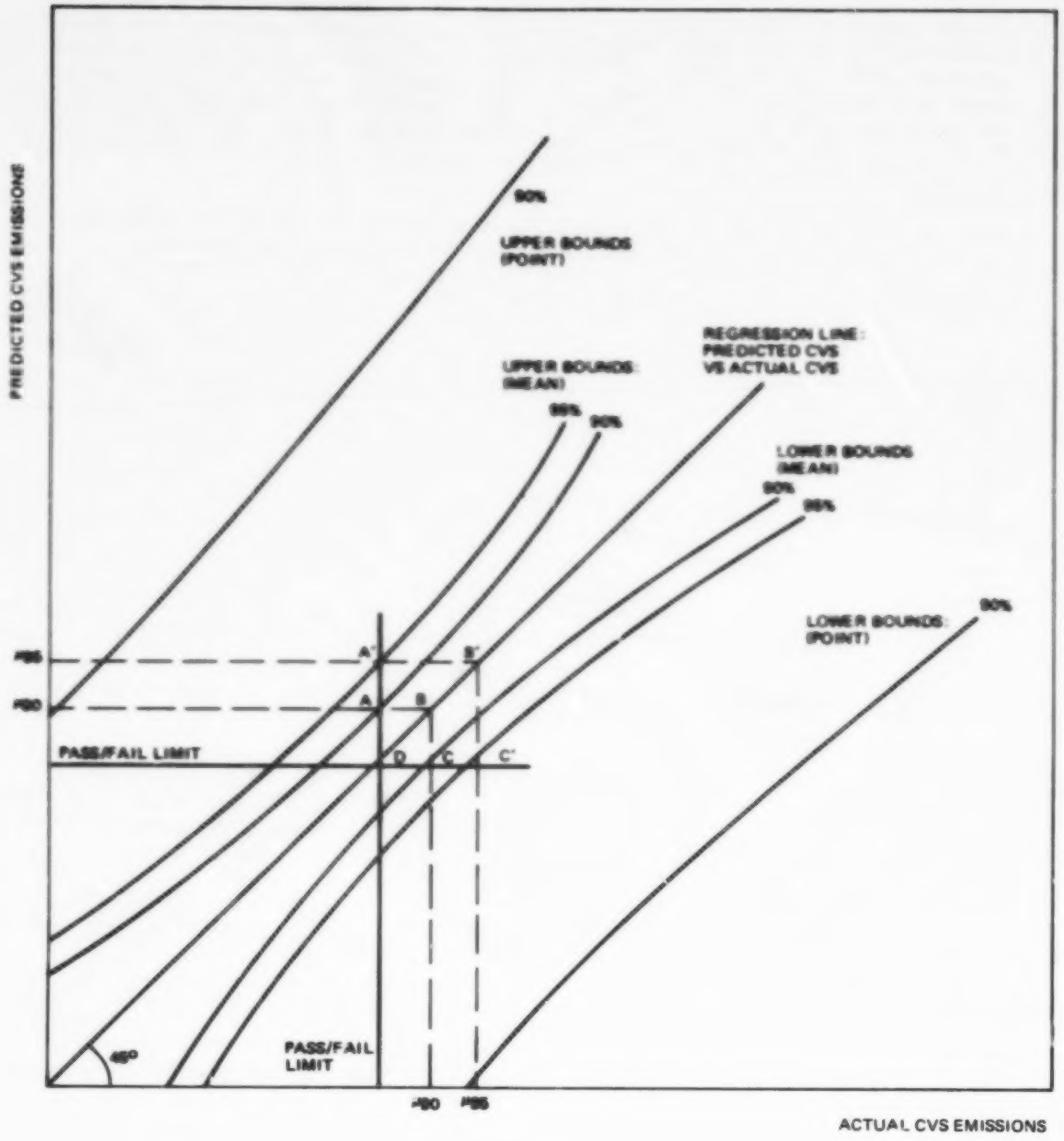


Figure 2-5. Confidence Bands of Predicted CVS Emission Levels

for the rejection rate being evaluated; i.e., any vehicle which was in the group which required service while in fact it exhibited true CVS emissions less than the mean predicted CVS value. At each percentile, commission errors were tabulated as a percentage of the total vehicles inspected. Figure 2-6 illustrates the process. Commission errors (CE) are shown in the upper left hand quadrant. Valid failed (VF) are shown in the upper right hand quadrant. The vehicles above the horizontal line are all failed vehicles according to the predicted CVS data.

The procedure was followed separately for each state, for HC and CO emissions, for the Idle and L.S.S. PVIM regimes and for controlled and uncontrolled vehicles. 1975 CVS data are described in the results. 1972 CVS data are not discussed but data are presented in Appendix C.

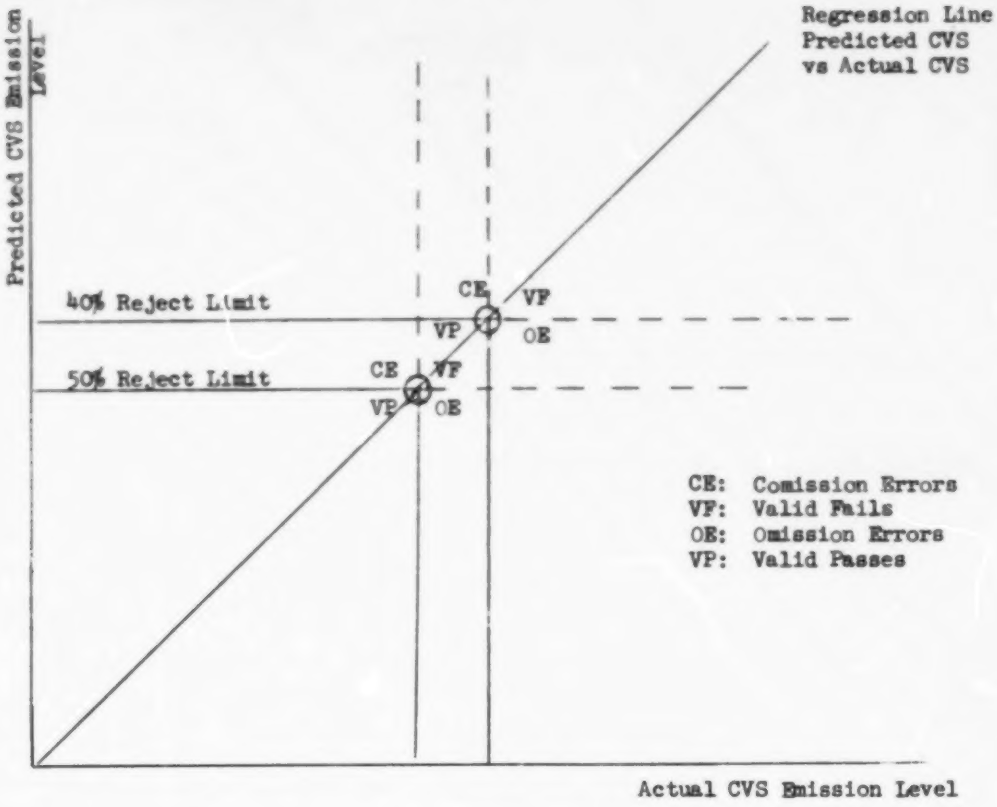

Regression Line
Predicted CVS
vs Actual CVS
Predicted CVS Emission Level
40% Reject Limit
50% Reject Limit
CE
VF
VP
OE
CE
VF
VP
OE
CE: Comission Errors
VF: Valid Fails
OE: Omission Errors
VP: Valid Passes
Actual CVS Emission Level

Figure 2-6. Errors of Commission Analysis

SECTION 3

PROGRAM RESULTS

This section presents and interprets the data generated during this project. Subsections are included for the following topics:

- Test Fleet Statistics
- Emission Reductions from Inspection and Maintenance
- Maintenance Requirements and Actions
- Cost of Inspection and Maintenance
- Cost Effectiveness of Inspection and Maintenance
- Correlation and Relatability of Inspection Tests to Federal Test Procedures

Data are presented for Phase I and Phase II separately, except for the Correlation and Relatability Analysis which is presented only for the combined Phase I and Phase II data.

This section is organized so that results and interpretation are grouped together in order to distinguish differences between:

- Idle and Loaded Steady State (L.S.S.)
- California and Michigan
- Phase I and Phase II

This organization provides a single topic in each paragraph. Some effects are dependent on more than one of the above factors. Therefore, some results are presented in more than one paragraph. Although creating some redundancy, this organization permits complete interpretation for each of the above factors.

3.1 TEST FLEET STATISTICS

This subsection describes the test fleet composition and inspection failure rates, and generally discusses several vehicle parameters which influence emissions levels. The average emission data in terms of 1975 Federal CVS procedures are presented for the Idle and L.S.S. test fleets. Statistical equivalence of the Idle and L.S.S. test fleet emission was determined using the t-test and F-test.

3.1.1 Test Fleet Vehicle Composition

Figures 3-1 and 3-2 show the number of vehicles in each major subfleet discussed in this report. Each Idle and L.S.S. fleet in Phase I and II contain 75 vehicles except for the Phase I Idle and L.S.S. fleets in Michigan which contained 74 vehicles. The data for the missing vehicles were discarded due to verified test errors.

The Idle and L.S.S. fleets were then divided into controlled and uncontrolled vehicles based upon mechanical inspection of the vehicle. In California the controlled vehicle subfleet generally included 1966 to 1971 model year vehicles. In Michigan the controlled vehicle subfleet generally included 1968 to 1971 model years. This was not always true, however, since some controlled 1966 - 1967 model year vehicles were found in Michigan and some uncontrolled 1966 - 1967 model year vehicles were found in California.

Failure limits were set to fail about 50% of each Idle and L.S.S. fleet during Phase I. During Phase II the limits were further adjusted to fail 50-60% of each controlled and uncontrolled vehicle subfleet. Table 3-1 presents the failure rate in percent for each controlled and uncontrolled vehicle subfleet. Phase I failure rates were generally lower than Phase II. Idle failure rates were generally lower than L.S.S. failure rates in California, but higher than L.S.S. failure rates in Michigan. During Phase II in California, more than 60% of the Idle and L.S.S. fleets were failed. This resulted from tighter rejection limits coupled with higher average emission levels than during Phase I. The analysis of effectiveness, cost, and cost effectiveness were presented for failure rates from 10% to 50%. Because a failure rate of approximately 30% was determined as optimum, the report generally discusses a 30% failure rate as discussed in Paragraph 2.5.

3.1.2 Dependence of Emissions on Vehicle Parameters

Several vehicle parameters were believed to influence emission levels: age, accumulated miles, weight, engine size, emission control, and manufacturer. These parameters, if not held constant for Idle and L.S.S., might confuse or influence the analysis of Idle and L.S.S. differences. The Idle and L.S.S. test fleets were selected so that differences in vehicles due to age, manufacturer and emission control system were minimized. The remaining factors (weight, miles, and engine size) were controlled as much as possible by the matching criteria for Idle and L.S.S. test fleets described in Paragraph 2.2.1.

After the test program the emission levels were analyzed to determine if they were, in fact, dependent upon these factors. All of the data for Phase I and Phase II were combined because these factors should be independent of the inspection and maintenance regime and location.

Table 3-2 summarized the before and after service emission level trends. Detailed emission tables are contained in Appendix B-1 of the report. The results may be summarized as follows for fleet average emission data before service:

- No trend in emissions appeared dependent upon vehicle make except that HC emissions were higher for the general class of "Imports" than for domestic makes. Imports generally use 4-cylinder engines

Figure 3-1. Distribution of Test Fleets – Phase I (30% Rejection Rate)

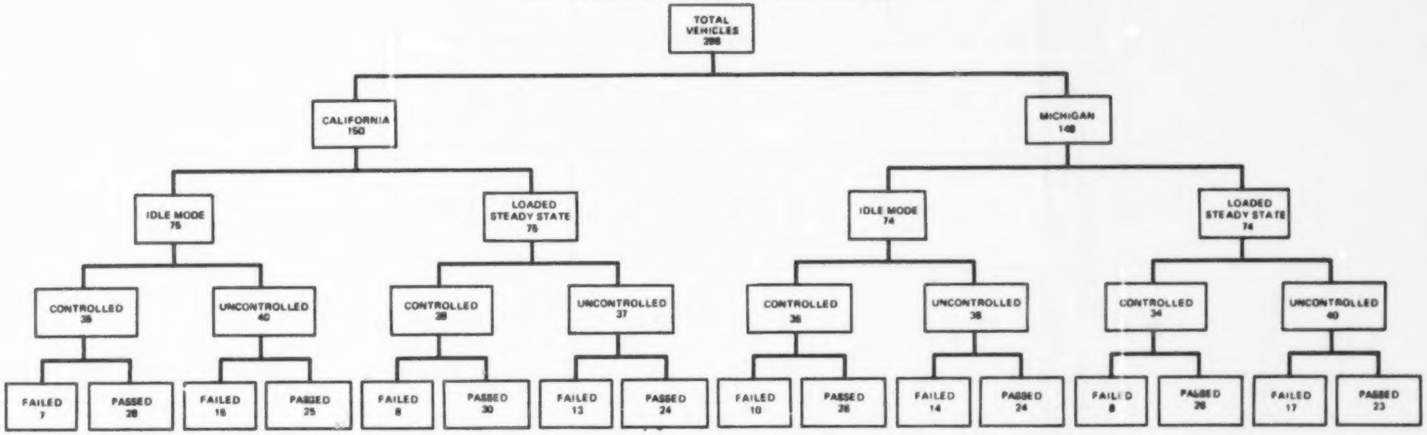

TOTAL VEHICLES 298
CALIFORNIA 150
MICHIGAN 148
IDLE MODE 75
LOADED STEADY STATE 75
IDLE MODE 74
LOADED STEADY STATE 74
CONTROLLED 35
UNCONTROLLED 40
CONTROLLED 38
UNCONTROLLED 37
CONTROLLED 36
UNCONTROLLED 38
CONTROLLED 34
UNCONTROLLED 40
FAILED 7
PASSED 28
FAILED 15
PASSED 25
FAILED 8
PASSED 30
FAILED 13
PASSED 24
FAILED 10
PASSED 26
FAILED 14
PASSED 24
FAILED 8
PASSED 26
FAILED 17
PASSED 23

Figure 3-2. Distribution of Test Fleets – Phase II (30% Rejection Rate)

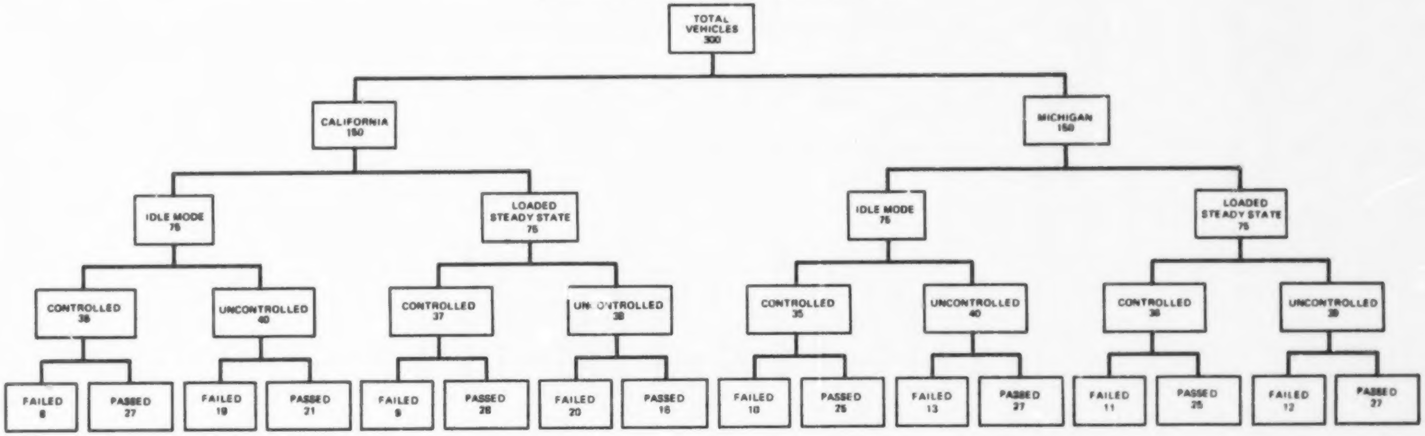

TOTAL VEHICLES 300
CALIFORNIA 150
MICHIGAN 150
IDLE MODE 75
LOADED STEADY STATE 75
IDLE MODE 75
LOADED STEADY STATE 75
CONTROLLED 35
UNCONTROLLED 40
CONTROLLED 37
UNCONTROLLED 38
CONTROLLED 35
UNCONTROLLED 40
CONTROLLED 36
UNCONTROLLED 39
FAILED 8
PASSED 27
FAILED 19
PASSED 21
FAILED 9
PASSED 28
FAILED 20
PASSED 18
FAILED 10
PASSED 25
FAILED 13
PASSED 27
FAILED 11
PASSED 25
FAILED 12
PASSED 27

Table 3-1
INSPECTION TEST FAILURE RATES
Percent of Inspected Vehicles

		California		Michigan		Combined	
		Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
FAILURE RATE AS RECEIVED	PHASE I						
	Controlled	20	53	43	38	31	46
	Uncontrolled	40	46	41	49	41	47
	Combined	31	49	42	44	36	47
	PHASE II						
	Controlled	49	51	57	50	53	51
	Uncontrolled	65	76	60	59	63	68
	Combined	57	64	59	55	58	59
30% FAILURE ANALYSIS	PHASE I						
	Controlled	20	21	28	27	24	22
	Uncontrolled	38	35	37	43	37	39
	Combined	29	28	32	34	31	31
	PHASE II						
	Controlled	23	24	29	31	26	27
	Uncontrolled	48	53	33	31	40	42
	Combined	36	39	31	31	33	35

Table 3-2

GENERAL TRENDS IN MASS EMISSIONS

PARAMETERS	BEFORE SERVICE			AFTER SERVICE		
	HC	CO	NO_x	HC	CO	NO_x
Vehicle Age	SI	I	D	I	I	D
Accumulated Mileage	I	I	D	I	I	SD
Vehicle Make	N[1]	N	N	N	N	N
Emission Control	2	2	2	3	3	3
Vehicle Weight	I	I	I	I	I	I

I = increasing emissions with increased value of parameter
D = decreasing emissions with increased value of parameter
N = no trend in emissions with increased value of parameter
S = slight trend in emissions with increased value of parameter, i.e., SI = slight increase
1 = imports tended to have higher emissions of HC than domestics
2 = crankcase only had highest HC and CO and lowest NO_x. Air injected vehicles had higher HC than engine modification vehicles but equal CO and NO_x
3 = crankcase only had highest HC and CO and lowest NO_x. Air injected vehicles had equal HC and equal or lower CO and NO_x than engine modification vehicles.

while domestic makes use 6 and 8-cylinder engines almost exclusively. There were also considerable differences in HC and CO emissions between vehicles manufactured by different divisions of a single manufacturer.

- Increased mileage exhibited a consistent trend to increase HC and CO emissions. This result would be expected and represents wear and deterioration. NO_x tended to decrease slightly with increased mileage.
- Increased vehicle age (represented by model year) exhibited a consistent trend to increase HC and CO emissions and decrease NO_x emissions. These trends are consistent with those for increased mileage. Increased mileage and age are mutually related variables.
- Increased vehicle weight exhibited a consistent trend to increase HC, CO and NO_x.
- Engine size was not evaluated since it is related to vehicle weight and cannot be isolated as an independent variable.
- Exhaust emissions of HC and CO were slightly higher for crankcase device equipped vehicles than uncontrolled vehicles and considerably higher than exhaust emission controlled vehicles. NO_x emissions were higher for controlled vehicles than uncontrolled and crankcase controlled vehicles.
- Vehicles equipped with air injection systems (found predominately in California) had higher emissions of HC than engine modification systems but generally equal emissions of CO and NO_x.

The above trends were also apparent after maintenance independent of PVIM procedures. Both maintenance procedures reduced scatter in the data making the trends more apparent.

Based upon these results, it was determined to group totally uncontrolled vehicles and crankcase device equipped vehicles into one class termed "Uncontrolled Vehicles". In a similar manner, the air injection system equipped vehicles and engine modification device equipped vehicles were grouped into one class termed "Controlled Vehicles". Since no dependence of emissions on vehicle make was determined, the effectiveness index grouped vehicles only by vehicle age. Because the emissions did depend upon age, weight, and mileage, vehicle procurement practices in the future should minimize differences in these factors by matching vehicles as was done in this project.

3.1.3 Test Fleet Emission Levels

This paragraph presents summary emission data for before service, after service, and after second service for each of the following groups:

- All vehicles - Table 3-3
- Serviced vehicles only - Table 3-4
- Controlled vehicles only - Table 3-5
- Uncontrolled vehicles only - Table 3-6

These tables contain data for Phase I and II separately. Tables 3-3, 3-5, and 3-6 reflect approximately an overall 30% failure rate, although the actual failure rates are shown in Table 3-1 for each subfleet.

Table 3-3 presents the emission levels for all vehicles in the Idle and L.S.S. fleets. In general, the emissions in Michigan and California are similar, although Phase II emissions tended to be higher than Phase I emissions in both Michigan and California. The standard deviation of emissions before maintenance tended to equal or exceed the mean value for HC and CO. After maintenance, the standard deviation was considerably less than the after service mean. Second service resulted in slightly lower mean emissions than first service.

Table 3-4 presents the emission levels for the serviced vehicles only. Combined Phase I emissions were generally lower than combined Phase II before maintenance. Standard deviations of HC were equal to the mean value before service while standard deviations of CO and NO_x were generally 50-70% of mean emissions. After service, the standard deviation of HC emission generally was reduced to 50-70% of the mean while standard deviations of CO and NO_x were not changed appreciably. Second service provided large emission reduction only for the Phase II Idle fleet in Michigan where HC emissions were reduced from 9.6 grams per mile after first service to 7.1 grams per mile after second service. The reduction was attributable to additional maintenance on uncontrolled Idle vehicles.

Table 3-5 shows the emission levels of controlled vehicles only. Controlled vehicles exhibited similar emission levels in California and Michigan although Phase II emission means tended to be higher than in Phase I. Standard deviations tended to be about half of the mean value both before and after maintenance. Second service was not effective in reducing emissions more than first service in any case. Typical before service emission levels of controlled vehicles were 4.5 to 5.0 grams per mile for HC, 60 grams per mile for CO and 4.0 to 4.5 grams per mile NO_x. California NO_x data for Phase I were unusually low (3 grams per mile).

Table 3-6 shows the emission levels of uncontrolled vehicles only. Uncontrolled vehicles in California had slightly lower emissions than in Michigan for Phase I while in Phase II, emission levels in Michigan were lower than in California. Overall, the mean emissions before service were 8.0 grams per mile for HC, 90 grams per mile for CO and 3.0 grams per mile for NO_x in Phase I. In Phase II, mean emissions before service were 10 to 11 grams per mile HC, 110 to 115 grams per mile CO, and 3.0 grams per mile NO_x. NO_x data in California during both phases were lower than in Michigan. Before service standard deviations of HC were generally less than the mean value during Phase I and equal to the mean in Phase II. Standard deviations of CO and NO_x were generally 50 - 60% of the mean before and after service. Second service was effective in creating additional emission reduction only for Phase II HC emissions of the Michigan Idle fleet.

Table 3-3
EMISSION LEVELS FOR ALL VEHICLES
1975 CVS Data

	No. of Cars	HYDROCARBONS (gm/mile)						CARBON MONOXIDE (gm/mile)						OXIDES OF NITROGEN (gm/mile)					
				After Service						After Service						After Service			
		Before		First		Second		Before		First		Second		Before		First		Second	
PHASE I		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
California	150																		
Idle	75	5.9	5.7	5.0	3.9	5.0	3.9	65.3	43.7	55.5	34.5	55.5	34.5	2.6	1.5	2.6	1.4	2.6	1.4
L.S.S.	75	6.3	5.1	5.0	3.6	5.0	3.6	72.2	44.6	65.6	42.0	64.2	39.7	2.6	1.5	2.6	1.5	2.6	1.5
Michigan	148																		
Idle	74	6.7	5.5	5.2	3.5	5.2	3.5	84.6	55.9	66.9	35.0	66.4	34.8	4.0	2.0	4.1	2.0	4.1	2.0
L.S.S.	74	6.6	5.5	5.3	3.1	5.3	3.1	78.0	49.1	62.0	34.7	61.9	34.8	4.2	1.9	4.1	1.9	4.2	1.9
Combined.	298																		
Idle	149	6.3	5.6	5.1	3.7	5.1	3.7	74.9	50.9	61.1	35.1	60.9	35.0	3.3	1.9	3.3	1.9	3.3	1.9
L.S.S.	149	6.4	5.3	5.1	3.4	5.1	3.2	75.0	46.8	63.8	38.4	63.1	37.2	3.4	1.9	3.3	1.9	3.4	1.8
PHASE II																			
California	150																		
Idle	75	7.9	8.4	6.0	4.7	6.0	4.7	93.0	51.4	80.2	41.6	80.0	41.8	3.4	1.7	3.3	1.6	3.3	1.6
L.S.S.	75	8.8	11.7	5.2	2.5	5.2	2.5	96.2	66.1	71.3	39.0	70.7	39.1	3.1	1.7	3.3	1.5	3.3	1.5
Michigan	150																		
Idle	75	8.6	9.2	7.2	7.7	6.4	4.4	86.2	42.9	73.7	39.4	73.7	39.1	4.1	1.6	4.3	1.7	4.3	1.7
L.S.S.	75	6.7	7.0	5.2	2.2	5.1	2.2	85.8	41.8	72.2	36.1	71.0	36.1	4.0	1.5	4.0	1.5	4.0	1.5
Combined	300																		
Idle	150	8.2	8.8	6.6	6.4	6.2	4.6	89.6	47.3	76.9	40.5	76.9	40.5	3.7	1.7	3.8	1.7	3.8	1.7
L.S.S.	150	7.8	9.7	5.2	2.4	5.2	2.4	91.0	55.4	71.7	37.4	70.8	37.5	3.5	1.7	3.6	1.6	3.6	1.5

Table 3-4
EMISSION LEVELS FOR SERVICED VEHICLES ONLY
1975 CVS Data

	No. of Cars	HYDROCARBONS (gm/mile)						CARBON MONOXIDE (gm/mile)						OXIDES OF NITROGEN (gm/mile)					
		Before		After Service				Before		After Service				Before		After Service			
				First		Second				First		Second				First		Second	
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
PHASE I	-																		
California	43																		
Idle	22	8.5	7.4	5.4	2.3	5.4	2.3	96.3	46.0	62.6	30.1	62.6	30.1	2.3	1.9	2.3	1.6	2.3	1.6
L.S.S.	21	10.0	6.1	5.4	2.9	5.3	2.8	98.7	49.8	75.1	50.3	70.3	43.8	2.0	1.3	1.9	1.4	1.9	1.4
Michigan	50																		
Idle	24	9.2	7.1	4.4	1.6	4.4	1.7	116.4	77.2	61.9	38.2	60.3	37.3	3.7	1.8	4.1	2.0	4.1	1.9
L.S.S.	26	10.3	7.5	6.5	4.2	6.5	4.2	112.4	50.1	67.0	29.0	66.7	29.5	3.4	1.7	3.4	1.4	3.4	1.4
Combined	93																		
Idle	46	8.9	7.1	4.9	2.0	4.9	2.0	106.8	64.3	62.2	34.2	61.4	33.7	3.0	2.0	3.2	2.0	3.3	2.0
L.S.S.	47	10.2	6.9	6.0	3.7	5.9	3.6	106.3	49.9	70.6	39.6	68.3	36.2	2.8	1.7	2.7	1.6	2.7	1.6
PHASE II																			
California	55																		
Idle	26	13.2	12.5	7.7	7.2	7.8	7.2	124.9	60.0	87.9	49.5	87.5	49.9	2.6	1.5	2.5	1.2	2.5	1.2
L.S.S.	29	15.5	16.8	6.2	3.3	6.2	3.3	138.3	82.3	73.7	47.0	72.1	47.4	2.5	1.8	3.0	1.5	3.0	1.5
Michigan	44																		
Idle	22	14.3	14.5	9.6	12.9	7.1	5.6	107.1	38.9	64.5	31.9	64.4	30.5	4.0	1.9	4.7	2.0	4.7	2.0
L.S.S.	22	10.3	11.9	5.2	2.1	4.8	2.1	108.4	40.1	61.8	25.3	57.8	23.6	3.5	1.4	3.7	1.4	3.7	1.3
Combined	99																		
Idle	48	13.7	13.3	8.6	10.1	7.5	6.5	116.7	51.7	77.2	43.5	76.9	43.3	3.3	1.8	3.5	1.9	3.5	1.9
L.S.S.	51	13.3	15.0	5.8	2.9	5.6	2.9	125.4	68.5	68.6	39.2	65.9	39.3	2.9	1.7	3.3	1.5	3.3	1.4

Table 3-5
EMISSION LEVELS FOR CONTROLLED VEHICLES ONLY
1975 CVS Data

	No. of Cars	HYDROCARBONS (gm/mile)						CARBON MONOXIDE (gm/mile)						OXIDES OF NITROGEN (gm/mile)					
				After Service						After Service						After Service			
		Before		First		Second		Before		First		Second		Before		First		Second	
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
PHASE I																			
California	73																		
Idle	35	4.4	5.0	3.4	2.0	3.4	2.0	53.4	33.2	47.7	28.1	47.7	28.1	2.8	1.3	2.7	1.3	2.7	1.3
L.S.S.	38	4.5	3.6	3.6	1.6	3.6	1.6	59.7	34.3	55.9	36.7	55.9	36.7	2.9	1.6	2.8	1.6	2.8	1.6
Michigan	70																		
Idle	36	4.6	2.0	3.8	1.6	3.9	1.6	65.3	40.5	52.7	37.4	51.7	36.6	5.0	1.8	5.0	2.0	5.0	1.9
L.S.S.	34	4.6	2.1	4.0	1.5	4.0	1.5	59.7	48.2	45.8	26.0	45.8	26.0	5.2	1.7	5.1	1.7	5.1	1.7
Combined	143																		
Idle	71	4.5	3.8	3.6	1.8	3.6	1.8	59.4	37.3	50.3	33.0	49.7	32.5	3.9	1.9	3.9	2.0	3.9	2.0
L.S.S.	72	4.5	3.0	3.8	1.6	3.8	1.6	59.7	41.1	51.1	32.3	51.1	32.3	4.0	2.0	3.9	2.0	3.9	2.0
PHASE II																			
California	72																		
Idle	35	4.1	1.5	3.9	1.3	3.9	1.3	63.5	33.0	56.8	31.1	56.7	31.2	4.3	1.4	4.3	1.4	4.3	1.4
L.S.S.	37	5.7	5.8	3.8	1.3	3.8	1.3	66.8	40.9	54.8	29.7	54.8	29.7	3.7	1.7	3.8	1.5	3.8	1.5
Michigan	71																		
Idle	35	5.2	3.1	4.7	2.8	4.7	2.8	62.3	32.3	51.5	29.2	51.5	29.2	4.7	1.5	5.2	1.7	5.2	1.7
L.S.S.	36	4.6	2.2	4.3	1.9	4.1	1.8	70.5	40.4	62.4	40.9	60.8	39.7	4.4	1.4	4.3	1.5	4.3	1.4
Combined	143																		
Idle	70	4.7	2.4	4.3	2.2	4.3	2.2	62.9	32.4	54.1	30.1	54.1	30.1	4.5	1.5	4.7	1.6	4.7	1.6
L.S.S.	73	5.1	4.4	4.1	1.7	4.0	1.6	68.6	40.4	58.5	35.6	57.8	34.9	4.0	1.6	4.0	1.5	4.0	1.5

Table 3-6

EMISSION LEVELS FOR UNCONTROLLED VEHICLES ONLY
1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons (gm/mile)						Carbon Monoxide (gm/mile)						Oxides of Nitrogen (gm/mile)					
		Before		After Service				Before		After Service				Before		After Service			
				First		Second				First		Second				First		Second	
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
PHASE I																			
California	77																		
Idle	40	7.2	6.0	6.4	4.6	6.4	4.6	75.8	49.3	62.2	38.3	62.2	38.3	2.4	1.6	2.4	1.4	2.4	1.4
L.S.S.	37	8.1	5.8	6.4	4.5	6.3	4.5	84.9	50.6	75.5	45.2	72.8	41.3	2.3	1.2	2.3	1.3	2.3	1.3
Michigan	78																		
Idle	38	8.7	6.9	6.4	4.4	6.4	4.4	102.8	62.6	80.3	26.7	80.3	26.7	3.0	1.7	3.2	1.7	3.2	1.7
L.S.S.	40	8.4	6.7	6.4	3.7	6.3	3.7	93.5	44.9	75.8	35.4	75.6	35.7	3.3	1.7	3.3	1.6	3.3	1.6
Combined	155																		
Idle	78	7.9	6.4	6.4	4.5	6.4	4.5	88.9	57.4	71.0	34.2	71.0	34.2	2.7	1.7	2.8	1.6	2.8	1.6
L.S.S.	77	8.2	6.2	6.4	4.1	6.3	4.1	89.4	47.6	75.7	40.1	74.2	38.3	2.8	1.6	2.8	1.5	2.9	1.5
PHASE II																			
California	78																		
Idle	40	11.2	10.5	7.9	5.7	7.9	5.7	118.9	50.9	100.6	39.2	100.5	39.3	2.6	1.4	2.5	1.2	2.5	1.2
L.S.S.	38	11.9	14.9	6.6	2.7	6.6	2.7	124.9	73.5	87.3	40.3	86.1	41.4	2.4	1.4	2.8	1.3	2.8	1.3
Michigan	79																		
Idle	40	11.5	11.5	9.4	9.8	8.0	5.0	107.1	40.4	93.2	37.0	93.1	36.4	3.5	1.5	3.5	1.3	3.6	1.3
L.S.S.	39	8.7	9.1	6.1	2.1	6.0	2.1	100.0	38.3	81.3	28.6	80.4	30.0	3.6	1.5	3.7	1.5	3.8	1.5
Combined	157																		
Idle	80	11.4	10.9	8.6	8.0	8.0	5.4	113.0	46.0	96.9	38.0	96.8	37.8	3.0	1.5	3.0	1.3	3.0	1.3
L.S.S.	77	10.3	12.3	6.3	2.4	6.3	2.4	112.3	59.3	84.2	34.9	83.2	35.9	3.0	1.6	3.3	1.5	3.3	1.5

Based on the sample sizes and variances (standard deviation squared), Figures 3-3, 3-4 and 3-5 present 95% confidence intervals about the before and after-second-service HC, CO and NO_x mean emissions when Phase I and II data were projected to a large (state) population. The purpose here was to graphically bound the population means which might be expected to occur in a large scale inspection and maintenance program.

In the case of HC and CO emissions, Idle and L.S.S. generally always achieved equivalent after-service means and confidence intervals during Phase I. During Phase II, L.S.S. generally achieved lower means and smaller after maintenance confidence intervals for HC and CO than Idle. Both Idle and L.S.S. had overlapping before and after confidence intervals for NO_x emission indicating no significant changes due to either PVIM regime.

3.1.4 Statistical Equivalence of Test Fleets Before Maintenance

The before-service emission data presented in Tables 3-3, 3-4, 3-5 and 3-6 were subjected to the t-test for equivalence of means and the F-test for equivalences of variances. All tests were performed at a 90% significance level. The results of these tests are presented below for the following cases:

Equivalence of Idle and L.S.S. fleets

Equivalence of California and Michigan fleets

Equivalence of Phase I and II fleets

3.1.4.1 Equivalence of Idle and L.S.S. Fleets - It was necessary to determine whether the Idle and L.S.S. test fleets had emission levels which were statistically equivalent prior to maintenance. The demonstration of statistical equivalence of Idle and L.S.S. would indicate that representative vehicle samples had been obtained and that valid comparison of Idle and L.S.S. effectiveness could be made by direct comparison of the emission reductions.

Before-service Idle and L.S.S. fleets had statistically equivalent mean emissions of HC, CO and NO_x in both Phase I and Phase II except for the controlled vehicles in Phase II where the NO_x emissions of the Idle fleet were statistically higher than the L.S.S. fleet. Before-service Idle and L.S.S. fleets had statistically equivalent HC, CO and NO_x emission variances in Phase I and Phase II except as indicated below:

- HC California controlled vehicles in Phase I (I > L.S.S.) and
  Phase II (I < L.S.S.)
  Combined states controlled vehicles in Phase I (I > L.S.S.)
  California uncontrolled vehicles and all vehicles in
  Phase II (I < L.S.S.)
  Michigan controlled vehicles and all vehicles in
  Phase II (I > L.S.S.)
  Combined states all vehicles in Phase II (I < L.S.S.)

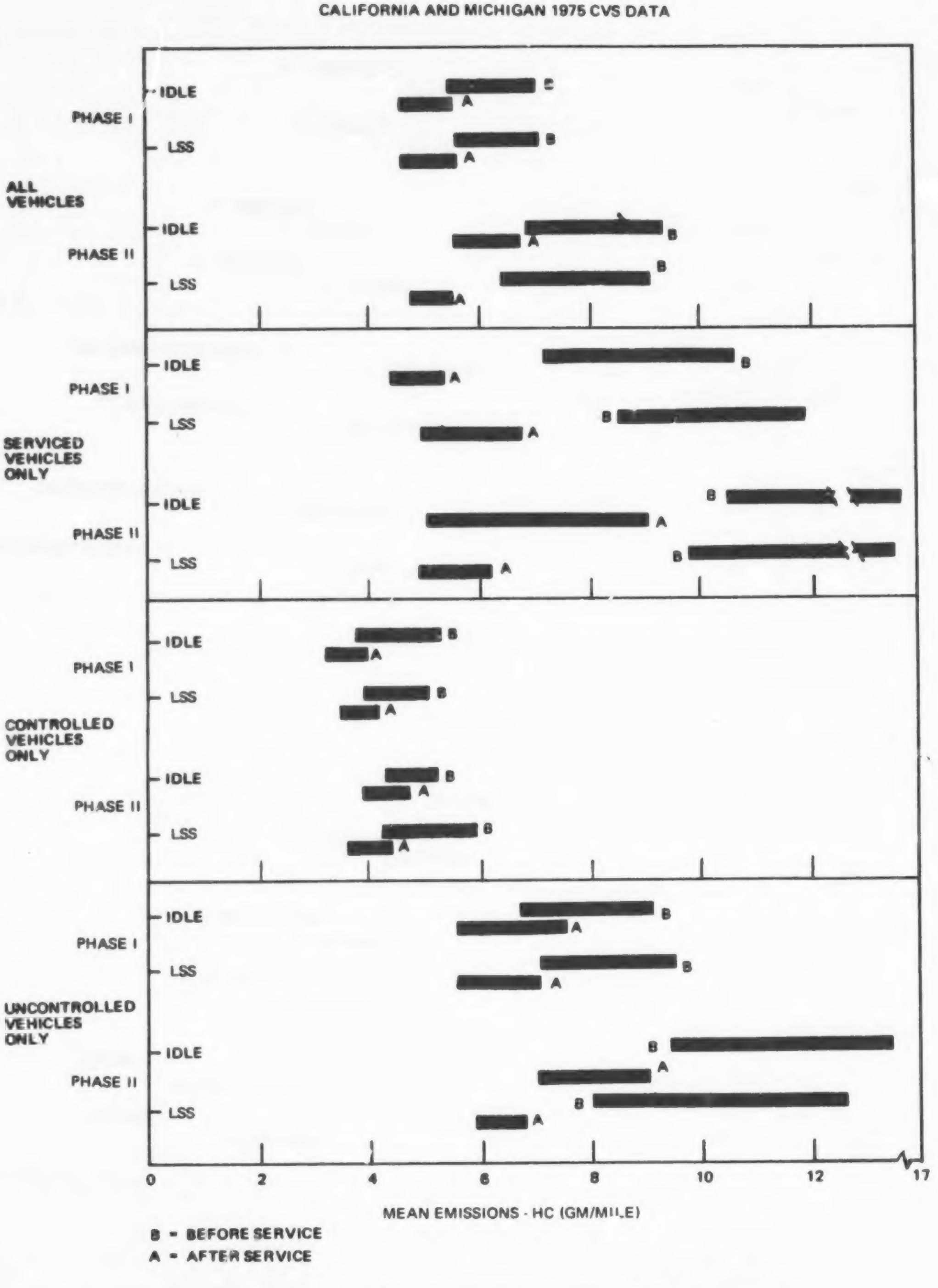


Figure 3-3. 95% Confidence Intervals of HC Before and After Service Fleet Means

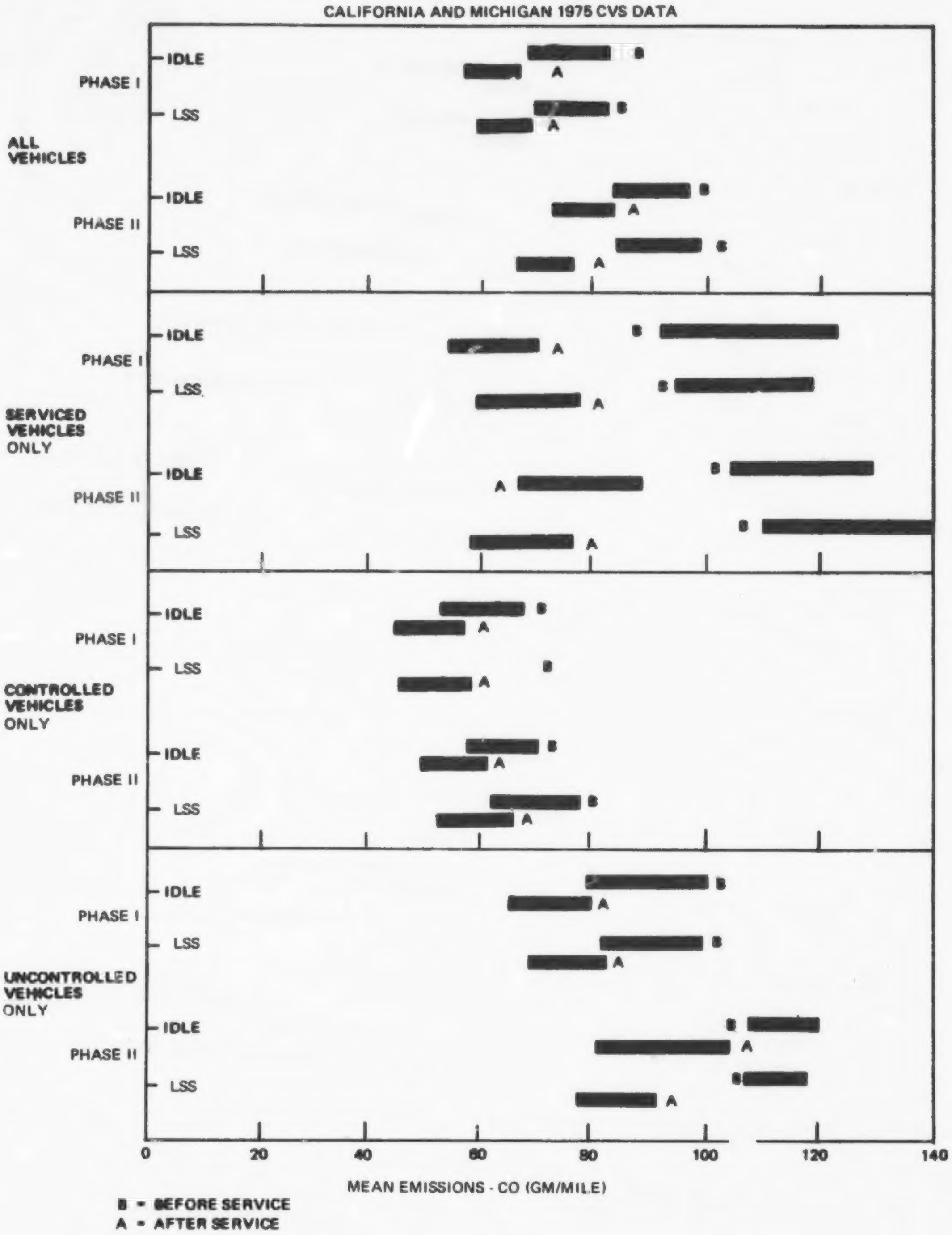


Figure 3-4. 95% Confidence Intervals of CO Before and After Service Fleet Means

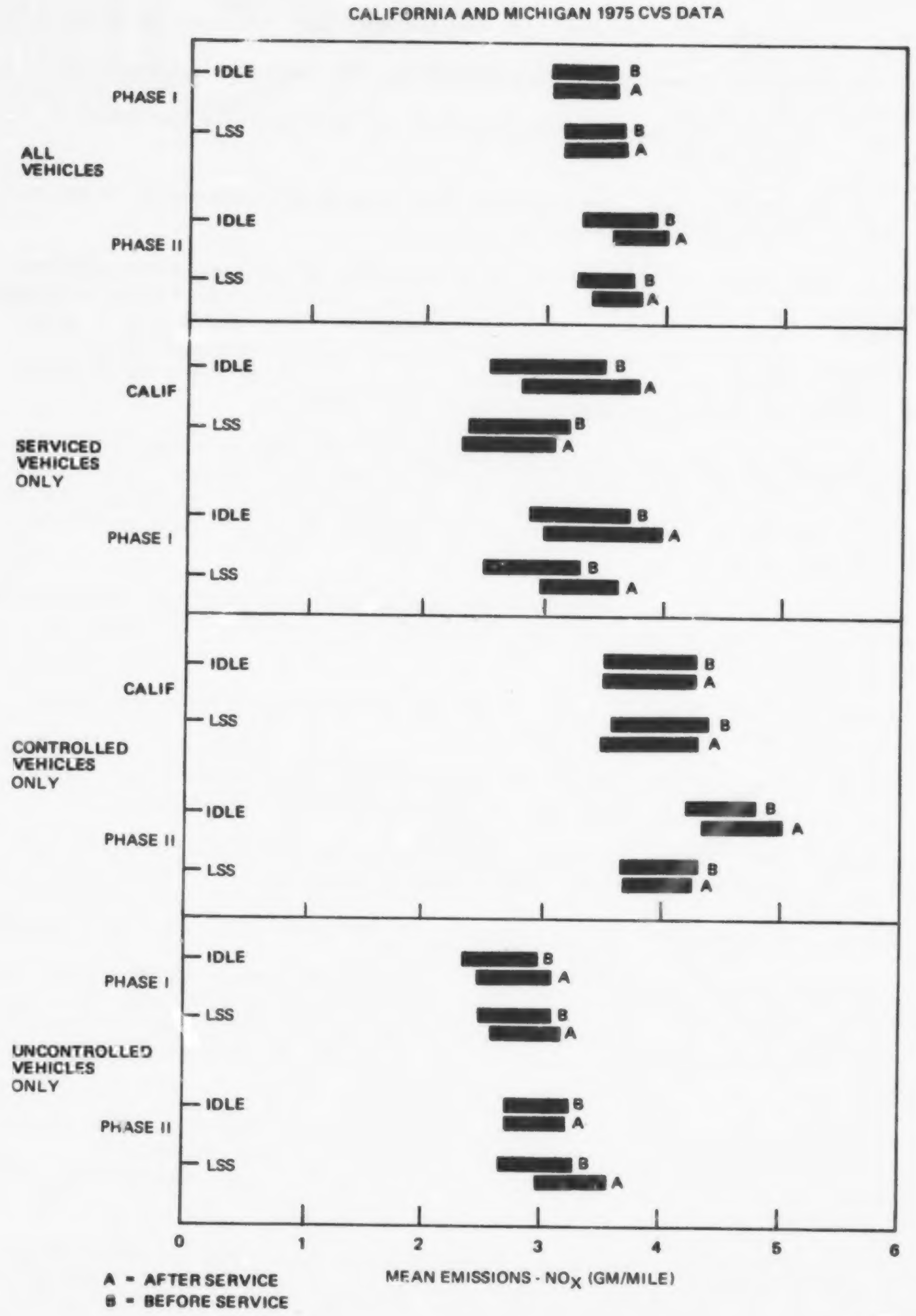


Figure 3-5. 95% Confidence Intervals of NO$_X$ Before and After Service Fleet Means

- CO Michigan serviced vehicles and uncontrolled vehicles in Phase I (I >L.S.S.)
  California uncontrolled vehicles and all vehicles in Phase II (I <L.S.S.)
  Combined states serviced vehicles and all vehicles in Phase II (I <L.S.S.)

- NO_x California serviced vehicles (I < L.S.S.) and controlled vehicles (I >L.S.S.) in Phase I.

In general, the fleet with higher variance contained a few more high emitters than the comparison fleet. Because of this, the fleet with the higher variance had a higher potential reduction than the comparison fleet and a larger emission reduction could be expected even if the mean values were equivalent. The emission reductions generally followed the above trends since fleets with higher variance achieved the higher emission reduction.

3.1.4.2 Equivalence of California and Michigan - The Idle and L.S.S. fleets in California were compared with their counterparts in Michigan. This analysis does not affect the evaluation of PVIM regime effectiveness. It does, however, establish if emission levels of in-service vehicles were different in California and Michigan.

Mean emission levels before service of HC and CO were found to be statistically equivalent in California and Michigan during Phase I and Phase II except as follows:

- HC Phase II L.S.S. California controlled vehicle emissions were lower than in Michigan.

- CO Phase I Idle California uncontrolled vehicles were lower than in Michigan resulting in all vehicles also being lower.

- CO Phase II L.S.S. California serviced vehicles and uncontrolled vehicles emissions higher than in Michigan.

- NO_x Phases I and II California emissions were lower than in Michigan.

Variances in emission levels before service were found not to be statistically equivalent. During Phase I, California variances of HC were greater than in Michigan while California CO variances were less than in Michigan. During Phase II, California variances of HC and CO emissions were greater than in Michigan.

The above results suggest that emission reductions in Phase I might be fairly uniform but that in Phase II, greater reductions of HC and CO could be expected in California than in Michigan. These results were obtained as shown in Section 3.2.

3.1.4.3 Equivalence of Phase I and Phase II - The test data for Idle and L.S.S. test fleets in California and Michigan were examined to determine if there were statistically significant differences in Phase I and Phase II emission data. In California, Phase II emission levels were 40% higher for HC and CO and 30% higher for NO_x and statistically unequal while CO and NO_x means were not equivalent. In Michigan, Phase I and Phase II emission means were statistically equivalent for HC, CO and NO_x.

Variance of HC and CO were generally not statistically equivalent between Phase I and Phase II. Phase II variances were usually higher than in Phase I and were greater than the mean value in many cases. NO_x variances were generally statistically equivalent.

Because of these differences, larger emission reductions of HC and CO would be expected during Phase II than Phase I in California, while in Michigan the emissions reductions in Phase I and Phase II should be equivalent. These results did occur, as shown in section 3.2.

3.2 EFFECTIVENESS ANALYSIS

This subsection describes the emission reductions obtained from Idle and L.S.S. PVIM. Tests of statistical significance were applied to determine if the reductions are statistically significant, and if so, which regime was statistically superior in reducing emissions. Emission reductions for inspection test failure rates of 10% to 50% were determined. Emission reductions achieved by correcting only idle emission failures are discussed. The effectiveness index for the first year concludes Section 3.2.

3.2.1 Test Fleet Emission Reductions

This paragraph presents the test fleet emission reductions in grams per mile and percent derived from Tables 3-3 through 3-6. These reductions represent approximately a 30% failure rate for each test fleet,as shown in Table 3-1.

Data is presented for the following groups:

All vehicles - Table 3-7

Service vehicles only - Table 3-8

Uncontrolled vehicles only - Table 3-9

Controlled vehicles only - Table 3-10

Table 3-7 presents emission reductions for all vehicles. Emission reductions were generally higher during Phase II than Phase I in California but equal for both Phases in Michigan. Reductions for the Idle fleet were around 1.4 grams per mile HC and 13 grams per mile CO. Reductions for the L.S.S. fleet were 1.3 grams per mile HC and 10 to 15 grams per mile CO in Phase I. During Phase II, L.S.S. reductions were 3.6 grams per mile HC and 26 grams per mile CO in California. The increase in effectiveness in California was due in part to improved garage performance and higher before-service emissions of the vehicles. In Michigan, the L.S.S. before-service emissions and emission reductions were not significantly different in Phase I and II.

Table 3-8 shows the emission reductions for the serviced vehicles only. Typical reductions for Idle and Phase I L.S.S. were 4.0 to 5.0 grams per mile HC, and 30 to 50 grams per mile CO. These reductions represented 40% to 50% reductions of HC and CO for the serviced vehicles. Average reductions for Phase II L.S.S. were 7.7 grams per mile HC and 60 grams per mile CO.

Table 3-9 presents emission reductions for controlled vehicles only. These vehicles exhibited relatively low reductions due to fairly small reductions on each serviced vehicle and the lower overall failure rates for controlled vehicles. Typical reductions were 1.0 gram per mile HC and 10 to 15 grams per mile CO for both Idle and L.S.S. These reductions represent 10% to 20% reductions of HC and CO in the total controlled vehicle fleet and 30% to 40% reductions for the serviced controlled vehicle fleet.

Table 3-7

EMISSION REDUCTIONS FOR ALL VEHICLES
1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons				Carbon Monoxide				Oxides of Nitrogen			
		Service Action				Service Action				Service Action			
		First		Second		First		Second		First		Second	
		gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%
PHASE I													
California	150												
Idle	75	0.9	15.3	0.9	15.3	9.8	15.0	9.8	15.0	0.0	0.0	0.0	0.0
L.S.S.	75	1.3	20.6	1.3	20.6	6.6	9.1	8.0	11.1	0.0	0.0	0.0	0.0
Michigan	148												
Idle	74	1.5	22.4	1.5	22.4	17.7	20.9	18.1	21.5	-0.1	-2.5	-0.1	-2.5
L.S.S.	74	1.3	20.0	1.3	20.0	16.0	20.5	16.1	20.6	0.1	2.4	0.0	0.0
Combined	298												
Idle	149	1.2	19.0	1.2	19.0	13.8	18.4	14.0	18.7	0.0	0.0	0.0	0.0
L.S.S.	149	1.3	20.3	1.3	20.3	11.2	14.9	11.9	15.9	0.1	2.9	0.0	0.0
PHASE II													
California	150												
Idle	75	1.9	24.1	1.9	24.1	12.8	13.8	13.0	14.0	0.1	2.9	0.1	2.9
L.S.S.	75	3.6	40.9	3.6	40.9	24.9	25.9	25.5	26.5	-0.2	-6.5	-0.2	-6.5
Michigan	150												
Idle	75	1.4	16.3	2.2	25.6	12.5	14.5	12.5	14.5	-0.2	-4.9	-0.2	-4.9
L.S.S.	75	1.5	22.4	1.6	23.9	13.6	15.9	14.8	17.2	0.0	0.0	0.0	0.0
Combined	300												
Idle	150	1.6	19.5	1.6	24.4	12.7	14.2	12.7	14.2	-0.1	-2.7	-0.1	-2.7
L.S.S.	150	2.6	33.3	2.6	33.3	19.3	21.2	20.2	22.2	-0.1	-2.9	-0.1	-2.9

Table 3-8

EMISSION REDUCTIONS FOR SERVICED VEHICLES ONLY
1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons				Carbon Monoxide				Oxides of Nitrogen			
		Service Action				Service Action				Service Action			
		First		Second		First		Second		First		Second	
		gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%
PHASE I													
California	43												
Idle	22	3.1	36.5	3.1	36.5	33.7	35.0	33.7	35.0	0.0	0.0	0.0	0.0
L.S.S.	21	4.6	46.0	4.7	47.0	23.6	23.9	28.4	28.8	0.1	5.0	0.1	5.0
Michigan	50												
Idle	24	4.8	52.2	4.8	52.2	54.5	46.8	56.1	48.2	-0.4	-10.8	-0.4	-10.8
L.S.S.	26	3.8	36.9	3.8	36.9	45.4	40.4	45.7	40.7	0.0	0.0	0.0	0.0
Combined	93												
Idle	46	4.0	44.9	4.0	44.9	44.6	41.8	45.4	42.5	-0.2	-6.7	-0.3	-9.1
L.S.S.	47	4.2	41.2	4.3	42.2	35.7	33.6	38.0	35.7	0.1	3.6	0.1	3.6
PHASE II													
California	55												
Idle	26	5.5	41.7	5.4	40.9	37.0	29.6	37.4	29.9	0.1	3.8	0.1	3.8
L.S.S.	29	9.3	60.0	9.3	60.0	64.6	46.7	66.2	47.9	-0.5	-20.0	-0.5	-20.0
Michigan	44												
Idle	22	4.7	32.9	7.2	50.3	42.6	39.8	42.7	39.9	-0.7	-17.5	-0.7	-17.5
L.S.S.	22	5.1	49.5	5.5	53.4	46.6	43.0	50.6	46.7	-0.2	-5.7	-0.2	-5.7
Combined	99												
Idle	48	5.1	37.2	6.2	45.3	39.5	33.8	39.8	34.1	-0.2	-6.1	-0.2	-6.1
L.S.S.	51	7.5	56.4	7.7	57.9	56.8	56.8	59.5	47.4	-0.4	-13.8	-0.4	-13.8

Table 3-9

EMISSION REDUCTIONS FOR CONTROLLED VEHICLES ONLY
1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons				Carbon Monoxide				Oxides of Nitrogen			
		Service Action				Service Action				Service Action			
		First		Second		First		Second		First		Second	
		gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%
PHASE I													
California	73												
Idle	35	1.0	22.7	1.0	22.7	5.7	10.7	5.7	10.7	0.1	3.6	0.1	3.6
L.S.S.	38	0.9	20.0	0.9	20.0	3.8	6.4	3.8	6.4	0.1	3.4	0.1	3.4
Michigan	70												
Idle	36	0.8	17.4	0.7	15.2	12.6	19.3	13.6	22.9	0.0	0.0	0.0	0.0
L.S.S.	34	0.6	13.0	0.6	13.0	13.9	23.3	13.9	23.3	0.1	1.9	0.1	1.9
Combined	143												
Idle	71	0.9	20.0	0.9	20.0	9.1	15.3	9.7	16.3	0.0	0.0	0.0	0.0
L.S.S.	72	0.7	15.6	0.7	15.6	8.6	14.4	8.6	14.4	0.1	2.5	0.1	2.5
PHASE II													
California	72												
Idle	35	0.2	4.9	0.2	4.9	6.7	11.8	6.8	10.7	0.0	0.0	0.0	0.0
L.S.S.	37	1.9	33.3	1.9	33.3	12.0	18.0	12.0	18.0	-0.1	2.7	0.1	-2.7
Michigan	71												
Idle	35	0.5	9.6	0.5	9.6	10.8	16.5	10.8	16.5	-0.5	-10.6	-0.5	-10.6
L.S.S.	36	0.3	6.5	0.5	10.9	8.1	11.5	9.7	13.8	0.1	2.3	0.1	2.3
Combined	143												
Idle	70	0.4	8.5	0.4	8.5	8.8	14.0	8.8	14.0	0.2	-4.4	0.2	-4.4
L.S.S.	73	1.0	19.6	1.1	21.6	10.1	14.7	10.8	15.7	0.0	0.0	0.0	0.0

TABLE 3-10

EMISSION REDUCTIONS FOR UNCONTROLLED VEHICLES ONLY
1975 CVS Data

Vehicle Fleet	No. of Cars	Hydrocarbons				Carbon Monoxide				Oxides of Nitrogen			
		Service Action				Service Action				Service Action			
		First		Second		First		Second		First		Second	
		gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%	gm/mi	%
PHASE I													
California	77												
Idle	40	0.8	11.1	0.8	11.1	13.6	17.9	13.6	17.9	0.0	0.0	0.0	0.0
L.S.S.	37	1.7	21.0	1.8	22.2	9.4	11.1	12.1	14.3	0.0	0.0	0.0	0.0
Michigan	78												
Idle	38	2.3	26.4	2.3	26.4	22.5	21.9	22.5	21.9	-0.2	-6.7	-0.2	-6.7
L.S.S.	40	2.0	23.8	2.1	25.0	17.7	18.9	17.9	19.1	0.0	0.0	0.0	0.0
Combined	155												
Idle	78	1.5	19.0	1.5	19.0	17.9	19.0	17.9	19.0	-0.1	-3.7	-0.1	-3.7
L.S.S.	77	1.8	22.0	1.9	23.2	13.7	15.3	15.2	17.0	0.0	0.0	-0.1	-3.6
PHASE II													
California	78												
Idle	40	3.3	29.5	3.3	29.5	18.3	15.4	18.4	15.9	0.1	3.8	0.1	3.8
L.S.S.	38	5.3	44.5	5.3	44.5	37.6	30.1	38.8	31.1	-0.4	-16.7	-0.4	-16.7
Michigan	79												
Idle	40	2.1	18.3	3.5	30.4	13.9	13.0	14.0	13.1	0.0	0.0	-0.1	-2.9
L.S.S.	39	2.6	30.0	2.7	31.0	18.7	18.7	19.6	19.6	-0.1	-2.8	-0.2	-5.6
Combined	157												
Idle	80	2.8	24.6	3.4	29.8	16.1	14.2	16.2	14.3	0.0	0.0	0.0	0.0
L.S.S.	77	4.0	38.8	4.0	38.8	28.1	25.0	29.1	25.9	-0.3	-10.0	-0.3	-10.0

Table 3-10 presents the emission reductions for uncontrolled vehicles only. Typical reductions were 2.0 to 3.0 grams per mile HC and 20 to 30 grams per mile CO. These reductions represented 10% to 30% reductions of HC and CO for the total uncontrolled vehicle fleet and 40% to 60% reductions of HC and CO for the serviced uncontrolled vehicle fleet. The uncontrolled vehicles were also responsible for the increase in NO_x emissions from the California L.S.S. fleet in Phase II. The increase accompanied the unusually large reductions of HC and CO.

3.2.2 Tests of Significance of Emission Reduction

This paragraph addresses the statistical significance of the emission reductions presented in the preceding section. The t-test was applied at the 90% significance level to determine if significant differences existed in the before and after-service emission data mean values. If significant difference existed, the analysis of covariance was applied at the 90% significance level to determine whether Idle of L.S.S. provided statistically greater emission reductions. The results of this analysis were presented for reductions obtained from first service data in Table 3-11. The following paragraphs discuss the results of these analyses.

3.2.2.1 Significant Differences in Idle and L.S.S. Emission Reductions

Both Idle and L.S.S. resulted in statistically significant reductions of HC and CO for the serviced vehicles and no statistically significant increase in NO_x. For the other three groups, however, Idle did not achieve statistically significant emission reductions in all cases. These were predominately in the Michigan test fleets. L.S.S. also did not always achieve statistically significant reductions in the controlled vehicle test fleets.

When subjected to the analysis of covariance, Idle achieved statistically larger reductions of HC than L.S.S. for serviced vehicles in Michigan during Phase I. L.S.S. achieved statistically larger emission reduction than Idle in several California cases during Phase II. In some cases, the covariance analysis established that Idle and L.S.S. were equally effective, i.e., had equal reductions; but the t-test indicated that only one achieved statistically significant emission reductions. In these cases, the regime which provided the statistically significant reduction was indicated. In cases where neither Idle nor L.S.S. statistically changed the mean value, the result of the covariance analysis was ignored.

The effectiveness of second service was examined by the t-test and analysis of covariance for those cases in which first service did not reduce emissions with statistical significance. Second service did not result in statistically significant changes from first service emission levels. However, the following statistically insignificant emission reductions after first service became statistically significant reductions after second service:

Phase I

California L.S.S. - CO: serviced cars

Michigan L.S.S. - HC: uncontrolled cars

Table 3-11

TEST OF SIGNIFICANCE OF EMISSION REDUCTIONS AFTER FIRST SERVICE

95% Level of Confidence
1975 CVS Data

	California			Michigan			Combined		
Vehicle Fleet	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
*All Vehicles									
Phase I	l	N	N	B	B	N	B	B	N
Phase II	B	L	N	l	B	N	L	L	N
Serviced Vehicles Only									
Phase I	B	i	N	I	B	N	B	B	N
Phase II	B	L	N	l	B	N	L	L	N
*Controlled Vehicles Only									
Phase I	N	N	N	i	N	N	B	N	N
Phase II	l	N	N	N	N	N	l	i	N
*Uncontrolled Vehicles Only									
Phase I	N	N	N	i	B	N	B	B	N
Phase II	B	L	N	l	l	N	L	L	N

*Approximately 30% of test fleets failed. Analysis of covariance statistically compensated for different means, variances, and sample sizes.

"I" indicates Idle provided statistically greater emission reduction than L.S.S.

"L" indicates L.S.S. provided statistically greater emission reduction than Idle.

"N" indicates neither Idle nor L.S.S. provided a statistically significant emission reduction or increase.

"B" indicates both Idle and L.S.S. provided statistically significant and equal emission reduction.

"i" indicates Idle provided a statistically significant emission reduction but L.S.S. did not.

"l" indicates L.S.S. provided a statistically significant emission reduction but Idle did not.

Phase II

Michigan Idle - HC: all cars, uncontrolled cars, serviced cars

Michigan L.S.S. - CO: controlled

The results of the analysis of covariance after second service are shown in Table 3-12. Second service provides statistically greater reductions of HC and CO for L.S.S. than for Idle in several additional cases. Again, Idle results in statistically greatest emission reductions only for HC in Phase I. Also note that Idle and L.S.S. were statistically equally effective on emission controlled vehicles in both states and on all groups in Michigan.

3.2.2.2 Significant Differences in Emission Reductions in California and Michigan

The principle distinction between California and Michigan was that L.S.S. was statistically superior to Idle in California, but in Michigan Idle and L.S.S. were equally effective in reducing emissions. A secondary distinction was that California emission reduction for both Idle and L.S.S. were larger than in Michigan. Both factors were related to the before-service emission profiles of Michigan and California. In California, there were more high emitting vehicles than in Michigan as shown by the F-test of variance. The high emitters provided the reductions required to show large reductions on the total fleet. Because of differences in before-service emissions and emission reductions in California and Michigan, data for the two states have been combined to compare Idle and L.S.S.

3.2.2.3 Significant Differences in Emission Reductions Between Phase I and Phase II

During Phase I, Idle and L.S.S. were always statistically equally effective in reducing emissions. During Phase II, L.S.S. was statistically more effective in reducing HC and CO in several situations than was Idle. The reason for this difference must, in part, be the improved instructions provided the L.S.S. garages prior to Phase II. In California, during Phase II the emissions levels were considerably higher for HC and CO, which provided both L.S.S. and Idle a better opportunity to reduce emissions. Both Idle and L.S.S. did provide better emission reductions in California during Phase II than during Phase I. The L.S.S. reductions, however, were statistically superior than Idle. Because of differences in the L.S.S. procedure and before service emission levels, the two phases have been treated separately.

3.2.3. Emission Reductions as a Function of Inspection Test Rejection Rate

Emissions reductions as a function of rejection (failure) rate for hydrocarbons and carbon monoxide are shown in Figures 3-6 and 3-7. Failure rates were developed for the controlled and the uncontrolled fleets in each phase. Controlled and uncontrolled vehicles were treated separately because different fleet emissions existed and, therefore, different rejection limits were used. The future application of the data to fleets in which the

Table 3-12

TESTS OF SIGNIFICANCE OF EMISSION REDUCTIONS AFTER SECOND SERVICE
95% Level of Confidence
1975 CVS Data

Vehicle Fleet	California			Michigan			Combined		
	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
*All Vehicles									
Phase I	l	N	N	B	B	N	B	B	N
Phase I	B	L	N	B	B	N	L	L	N
Serviced Vehicles Only									
Phase I	B	i	N	I	B	N	B	B	N
Phase II	B	L	N	B	B	N	B	L	N
*Controlled Vehicles Only									
Phase I	N	N	N	i	N	N	B	N	N
Phase II	l	l	N	N	N	N	l	B	N
*Uncontrolled Vehicles Only									
Phase I	N	N	N	B	B	N	B	B	N
Phase II	B	L	N	B	l	N	L	L	N

*Approximately 30% of test fleets failed. Analysis of covariance statistically compensated for different means, variances, and sample sizes.

"I" indicates Idle provided statistically greater emission reduction than L.S.S.

"L" indicates L.S.S. provided statistically greater emission reduction than Idle.

"N" indicates neither Idle nor L.S.S. provided a statistically significant emission reduction or increase.

"B" indicates both Idle and L.S.S. provided statistically significant and equal emission reduction.

"i" indicates Idle provided a statistically significant emission reduction but L.S.S. did not.

"l" indicates L.S.S. provided a statistically significant emission reduction but Idle did not.

CALIFORNIA AND MICHIGAN 1975 CVS DATA

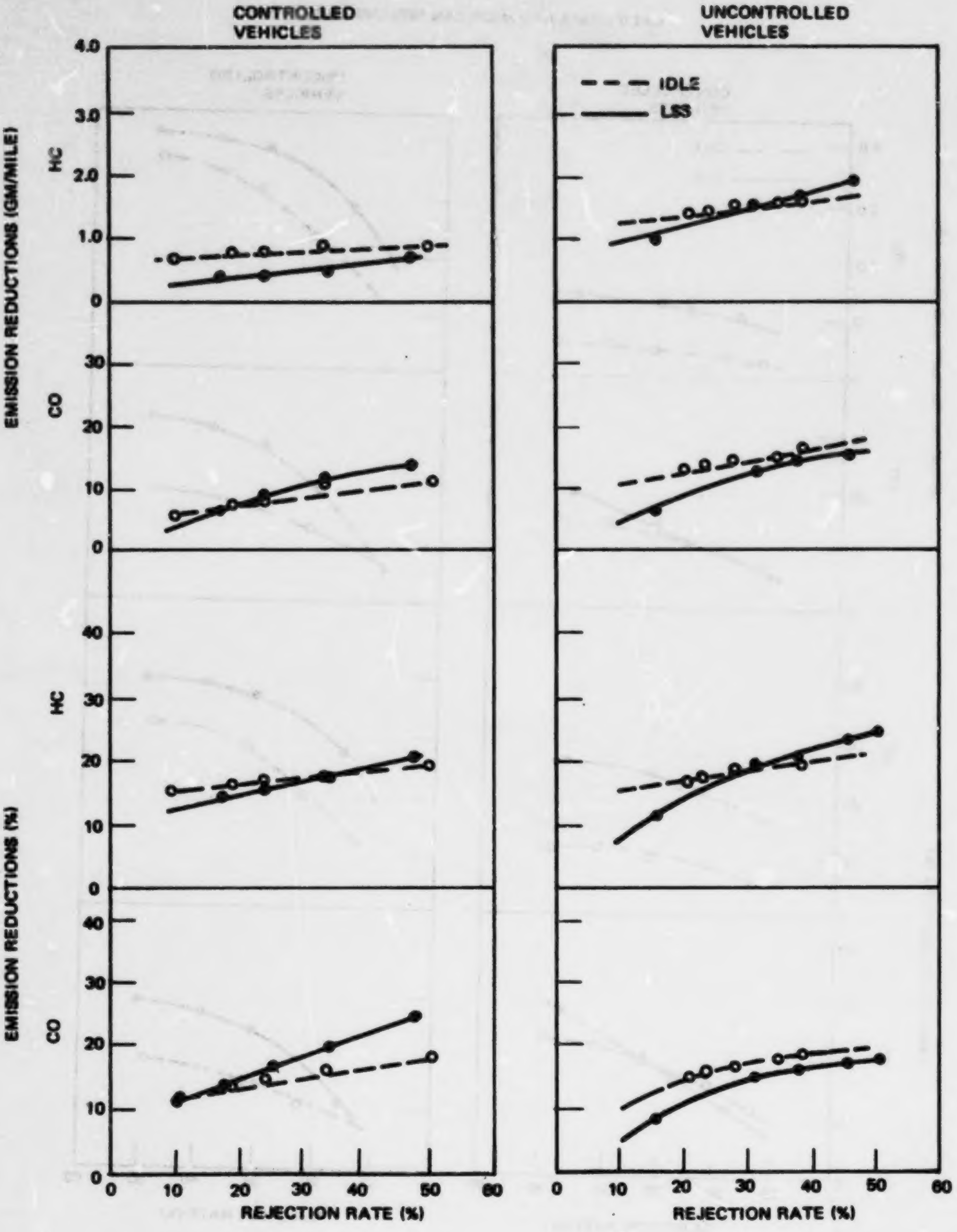


Figure 3-6. Effectiveness as a Function of Rejection Rate -- Phase I

CALIFORNIA AND MICHIGAN 1975 CVS DATA

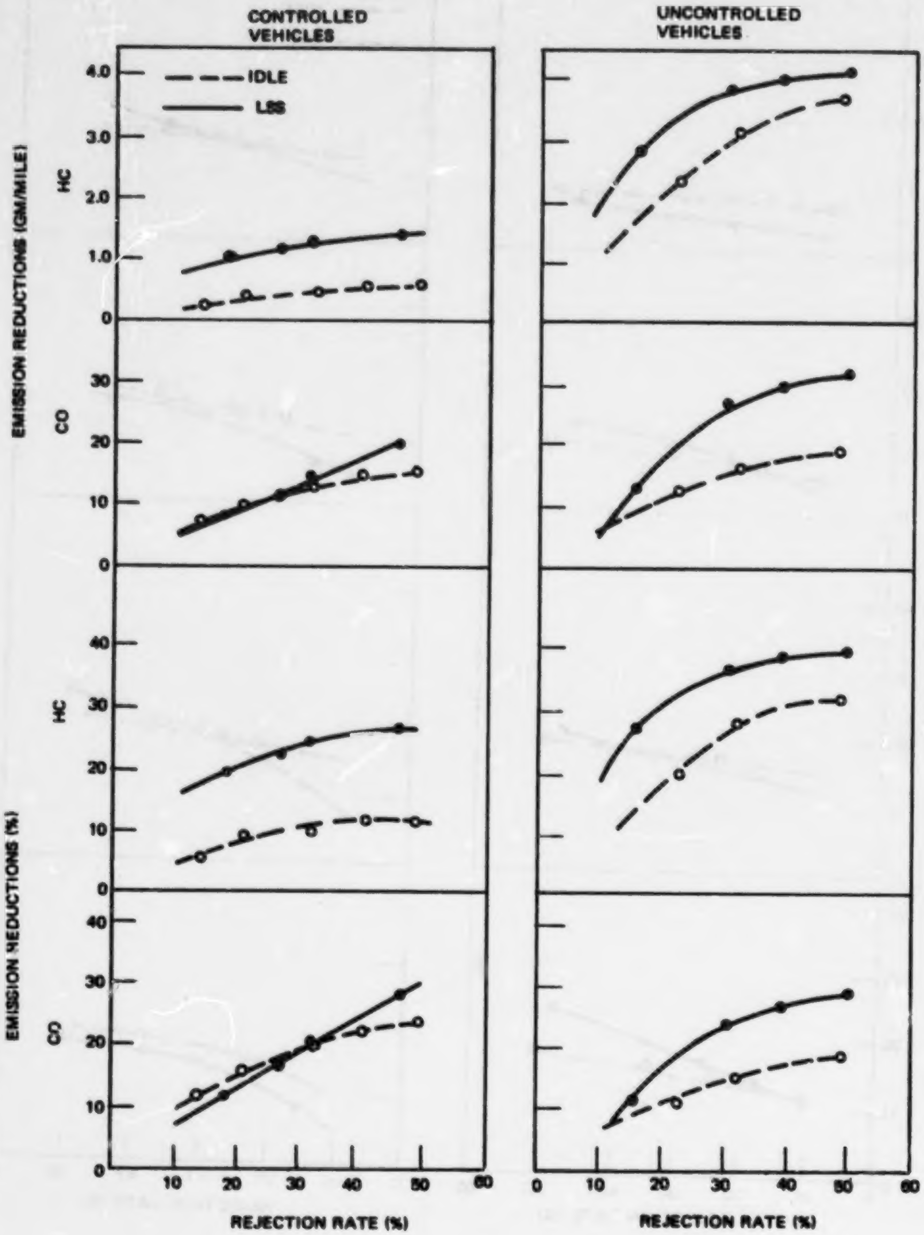


Figure 3-7. Effectivness as a Function of Rejection Rate – Phase II

fraction of uncontrolled vehicles is reduced is enhanced by this procedure. Emission reductions were calculated for each set of emission levels shown in Table 2-6 and plotted as a function of the resulting rejection rate. A vehicle included in a given rejected population on a CO plot may be included because it failed an HC limit and vice versa for a vehicle included in an HC plot.

In Phase I, Idle and L.S.S. were essentially equally effective in reducing HC and CO at all rejection rates. In Phase II, L.S.S. achieved higher reductions of HC and CO than Idle except that they were equally effective in reducing CO emissions from controlled vehicles at less than 30% rejection rate. Statistical significance of reductions was not evaluated. In general, 70% to 80% of the emission reductions achieved at 50% to 60% rejection rates were achieved at a 30% rejection rate.

3.2.4 Effectiveness of Correcting Idle Only Emission Failures

Most vehicles in the L.S.S. fleets failed emission inspection only because of idle failures. Very few Idle vehicles would have failed L.S.S. cruise modes if they had been in the L.S.S. fleet. Therefore, Idle and L.S.S. might logically be expected to show similar effectiveness since the malfunctions detected and corrected by each regime would be the same. L.S.S., because of its improved diagnostic information, may be expected to provide these emission reductions at lower cost than Idle since the L.S.S. garages would know that the malfunction was purely idle system-related while the Idle garage would not. The Idle garages, therefore, may attempt more extensive repair than was actually required to correct the idle system malfuction.

The analysis of idle only failures represented in Table 3-13, was performed by determining emission reductions for those Idle vehicles which failed the Idle Mode inspection and would not have failed any cruise modes of the L.S.S. test. Those L.S.S. vehicles which failed the idle portion of the L.S.S. without failing any cruise mode were analyzed to determine their emission reductions.

L.S.S. was more effective than Idle in reducing HC and CO emissions in both Phase I and Phase II. In Phase I, L.S.S. achieved approximately 50% greater reductions of HC and 60% greater reductions of CO than did Idle. In Phase II, L.S.S. achieved approximately 50% greater reductions of HC and 33% greater reductions of CO than did Idle. Neither Idle nor L.S.S. changed NO_x significantly.

The emission reductions on serviced vehicles with idle only inspection failures are presented in Table 3-14. The CO emission reductions achieved by L.S.S. were 25% greater than Idle in both Phases; and the HC emission reductions achieved by L.S.S. were 20% greater in Phase I and 60% greater in Phase II than the reductions achieved by Idle. Idle vehicles failing only at idle experienced an average emission reduction of 2 to 3 grams per mile HC and 33 grams per mile CO. L.S.S. vehicles failing only at idle experienced an average emission reduction of 3.3 grams per mile HC and 44 grams per CO.

Table 3-15 compares the fleet average emission reduction achieved by vehicles with idle only emission failures and the reductions achieved by servicing

Table 3-13

FLEET EMISSION REDUCTION FROM CORRECTING IDLE ONLY FAILURES
(1975 CVS Grams per Mile)

Vehicle Fleet	Phase I				Phase II			
	HC	CO	NO_x	Sum	HC	CO	NO_x	Sum
California								
Idle	0.46	3.63	0.01	4.10	0.36	3.80	0.04	4.20
L.S.S.	0.54	4.06	0.07	4.67	0.52	7.17	-0.03	7.66
Michigan								
Idle	0.44	6.82	-0.05	7.21	0.44	9.47	-0.11	9.80
L.S.S.	0.86	12.70	-0.04	13.52	0.67	10.49	-0.03	11.13
Combined								
Idle	0.45	5.23	-0.02	5.66	0.40	6.64	-0.04	7.00
L.S.S.	0.70	8.38	-0.02	9.06	0.60	8.83	-0.03	9.40

Table 3-14

SERVICED VEHICLE EMISSION REDUCTION FROM
CORRECTING IDLE ONLY FAILURES
(1975 CVS Grams per Mile)

Vehicle Fleet	Phase I				Phase II			
	HC	CO	NO_x	Sum	HC	CO	NO_x	Sum
California								
Idle	2.88	22.68	0.06	25.62	2.06	21.94	0.23	24.23
L.S.S.	3.40	25.37	0.43	29.20	3.23	44.82	-0.21	47.84
Michigan								
Idle	2.73	42.32	-0.29	44.76	2.04	44.41	-0.53	45.92
L.S.S.	3.36	49.46	-0.14	52.68	3.13	49.16	-0.12	52.17
Combined								
Idle	2.81	32.50	-0.12	35.19	2.05	34.34	-0.19	36.20
L.S.S.	3.38	40.13	0.08	43.43	3.17	47.30	-0.16	50.31

Table 3-15

RELATIVE EFFECTIVENESS OF CORRECTING IDLE ONLY FAILURES* PERCENT OF FLEET AVERAGE EMISSION REDUCTION

Vehicle Fleet	Phase I			Phase II		
	HC	CO	NO_x	HC	CO	NO_x
California						
Idle	51%	37%	-	19%	29%	40%
L.S.S.	42%	51%	-	14%	28%	15%
Michigan						
Idle	29%	38%	50%	20%	73%	55%
L.S.S.	66%	79%	-	42%	71%	-
Combined						
Idle	38%	37%	-	29%	52%	40%
L.S.S.	54%	70%	-	23%	44%	33%

*Emission reductions shown in Table 3-13 divided by emission reductions shown in Table 3-7 multiplied by 100%

-Indicates value in Table 3-7 is zero.

all vehicles. The relative effectiveness of servicing only vehicles with idle inspection failures depends upon the number of vehicles with cruise failures. Fleets composed primarily of idle failures, like Michigan Phase II, show relatively high effectiveness for the idle failures (70%), while fleets with more cruise problems, like California Phase II, show relatively poor effectiveness for the idle failures (20%).

3.2.5 Effectiveness Index

To provide a single measure of emission reduction effectiveness, the three pollutants were weighted and combined in a linear model described more fully in Paragraph 2.3.3.4. This model utilized the gram per mile and percent emission reductions developed for each model year group in the preceding discussion, and combined these reductions using appropriate weighting factors to account for the difference in annual mileage accumulation and distribution of ages within the total vehicle populations of California and Michigan. This index provided a means of calculating tons per year of emissions prevented from entering the atmosphere by inspection and maintenance. The index assumed that the inspection program was in effect, that the emission reductions achieved in this study were uniform throughout all of California and Michigan, and that degradation of emission reductions did not occur. No attempt was made to extrapolate these predictions into the future since the behavior of future vehicles on the road and in an inspection and maintenance program could not be accurately forecast. Tables 3-16 and 3-17 present the emission reductions (Wn) used in the effectiveness model.

The results of the effectiveness index are presented separately for each pollutant using the following pollutant weighting factors:

HC = 1.00 CO = 1.00 NO_x = 1.00

HC = 0.33 CO = 0.33 NO_x = 0.33

HC = 0.60 CO = 0.10 NO_x = 0.30

The first set of weighting factors represented the direct sum of the emission reductions in tons per year. The last two sets of weighting factors did not reflect a true value of tons per year emission reduction. The last set of factors provided a measure of emission reduction effectiveness which did not weight carbon monoxide as heavily as the direct sum. Therefore, this weighting factor provided an index more appropriate for a region where photochemical products are considered a more significant problem than carbon monoxide. Since carbon monoxide has the largest mass, as well as a high percent reduction, the effect of the carbon monoxide emission reductions tended to dominate the reductions of hydrocarbons or increases of oxides of nitrogen. The development of the weighting factors is discussed in paragraph 2.3.3.4.

Table 3-18 presents the results of the effectiveness index in terms of tons per year and percent reductions based on an approximate 30% rejection rate. Reductions are shown for each pollutant and their weighted sum. In Phase I, Idle was slightly more effective in reducing emissions than L.S.S. In Phase II, L.S.S. was more effective than Idle in reducing emissions, and in

Table 3-16

EFFECTIVENESS INDEX INPUT DATA
Grams Per Mile Reduction - 1975 CVS Data

Vehicle Fleet	1970-1971			1968-1969			1966-1967			1962-1965			1956-1961		
	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
PHASE I															
California															
Idle	0.1	4.4	0.0	0.1	2.3	0.2	4.0	21.0	-0.4	0.4	10.2	0.2	0.1	12.1	0.0
L.S.S.	0.0	1.9	-0.1	0.4	2.4	0.2	2.5	9.5	0.1	1.7	21.1	-0.1	1.7	-1.7	-0.1
Michigan															
Idle	0.4	10.7	-0.3	1.0	15.7	0.0	0.7	8.8	-0.2	4.0	37.5	-0.2	-	-	-
L.S.S.	0.2	5.7	0.2	0.6	10.6	0.0	1.7	29.3	0.1	3.0	22.1	-0.2	-	-	-
Combined															
Idle	0.3	7.9	-0.1	0.6	9.9	0.1	2.3	14.5	-0.3	2.1	22.8	0.0	0.1	9.5	0.0
L.S.S.	0.1	4.0	-0.1	0.5	6.9	0.1	2.1	19.7	0.1	2.4	21.6	-0.1	1.3	-0.7	0.0
PHASE II															
California															
Idle	0.4	10.2	-0.2	0.2	7.2	0.0	3.3	13.0	0.0	2.8	15.4	0.2	2.2	19.3	0.0
L.S.S.	1.2	8.2	0.0	2.7	13.2	0.0	1.5	23.4	-0.3	8.0	41.1	-0.1	1.6	34.3	-0.6
Michigan															
Idle	0.7	9.5	-0.3	0.5	11.4	-0.5	1.0	7.4	-0.1	6.2	22.1	0.0	-	-	-
L.S.S.	0.2	3.7	0.3	0.6	14.0	-0.1	0.7	18.0	0.0	4.7	23.8	-0.3	-	-	-
Combined															
Idle	0.5	9.7	-0.2	0.4	9.5	-0.3	2.0	9.9	-0.1	4.5	18.6	0.1	1.9	15.5	-0.1
L.S.S.	0.7	5.8	0.2	1.6	13.6	0.0	1.0	20.6	-0.2	6.4	32.8	-0.2	1.2	27.0	-0.5

Table 3-17

EFFECTIVENESS INDEX INPUT DATA
Percent Reductions - 1975 CVS Data

Vehicle Fleet	1970-1971			1968-1969			1966-1967			1962-1965			1956-1961		
	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
PHASE I															
California															
Idle	3.6	10.4	0.0	2.6	4.4	6.9	43.0	27.7	-16.7	7.0	15.7	6.9	1.2	12.4	0.0
L.S.S.	0.0	4.5	-3.2	9.8	3.9	6.7	29.0	13.6	3.8	23.0	20.4	-5.0	21.2	-2.5	-4.0
Michigan															
Idle	9.1	18.2	-5.7	22.2	22.3	0.0	11.5	10.6	-6.5	36.7	30.8	-7.4	-	-	-
L.S.S.	5.4	12.0	3.7	13.0	18.0	0.0	21.0	27.3	2.8	29.4	21.6	-7.1	-	-	-
Combined															
Idle	8.1	15.4	-2.4	14.3	15.9	2.6	30.3	18.1	-10.7	25.9	25.0	0.0	1.1	10.0	0.0
L.S.S.	2.9	8.9	-2.3	11.4	11.4	2.3	25.0	22.1	3.2	27.3	21.0	-4.2	18.1	-1.1	0.0
PHASE II															
California															
Idle	11.4	21.2	-4.9	4.8	11.8	0.0	36.7	12.6	0.0	28.0	12.6	7.4	17.7	16.4	0.0
L.S.S.	26.7	18.9	0.0	39.7	17.2	0.0	25.0	26.6	-10.0	53.0	31.1	-3.7	20.8	28.7	-30.0
Michigan															
Idle	15.9	16.1	-6.7	8.8	18.0	-10.4	11.2	6.7	-3.1	42.5	19.5	0.0	-	-	-
L.S.S.	4.7	5.5	6.8	12.5	19.2	-2.3	10.0	17.8	0.0	43.9	22.7	-9.0	-	-	-
Combined															
Idle	12.5	17.9	-4.5	7.8	15.3	-6.3	22.5	9.3	-3.2	36.6	15.8	3.1	16.5	14.3	-4.0
L.S.S.	15.9	10.2	4.8	28.0	18.2	0.0	15.4	21.6	-5.9	49.2	27.5	-6.7	17.1	25.3	-19.2

Table 3-18

FIRST YEAR EFFECTIVENESS INDEX - 1975 CVS DATA
30% Rejection Rate

1973 Emission Reduction	California				Michigan				Combined			
	Phase I		Phase II		Phase I		Phase II		Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
HC % Reduction	7.3%	10.4%	12.9%	23.5%	14.2%	11.7%	13.4%	12.2%	9.7%	10.9%	13.1%	19.5%
Tons/year x 10^3	87	116	169	344	57	50	76	57	144	166	245	401
CO % Reduction	9.1%	6.3%	9.6%	15.9%	14.8%	13.7%	11.1%	11.5%	11.1%	8.9%	10.1%	14.3%
Tons/year x 10^3	914	817	1218	2335	702	622	490	565	1616	1439	1708	2900
NO_x % Reduction	0.3%	-0.2%	0.6%	-3.8%	-3.2%	-0.1%	-4.0%	-0.7%	-0.9%	-1.3%	-1.0%	-2.7%
Tons/year x 10^3	2.7	-2.7	1.0	-14.0	-6.5	1.1	-9.9	-0.8	-2.9	-0.3	-3.4	-4.5
Tons/year x 10^3 1:1:1	1004	930	1388	2665	753	673	557	621	1757	1603	1945	3286
Tons/year x 10^3 0.33:0.33:0.33	334	310	463	888	251	224	186	207	586	534	648	1095
Tons/year x 10^3 0.6:0.1:0.3	144	152	224	436	103	92	92	90	247	144	316	526

California was nearly twice as effective as Idle. Percent reductions were typically 10% to 15% for HC and CO by Idle and L.S.S. Phase II L.S.S. emission reductions of HC in California were 24% due to a relatively high number of ignition failures compared to the other fleets.

3.3 INSPECTION AND MAINTENANCE ANALYSIS

The results of the inspection and maintenance analysis included the following sections:

> Modal failure analysis which identified the frequency of inspection test failures by mode.
>
> Diagnosis of the failed vehicles indicating the minimum required repair action.
>
> Repair action summary and service actually performed.
>
> Unjustified repair actions which were ineffective in reducing emissions.
>
> An engineering evaluation of the failing vehicles which were exited.

3.3.1 Inspection Test Modal Failures

Table 3-19 shows the incidence of L.S.S. and Idle inspection test failures including the number of L.S.S. vehicles which failed only idle, low and/or high cruise modes, and those which failed any of the cruise modes plus idle. The total number of vehicles are shown by phase, emission control class, and state. The table is further categorized by the pollutant such as CO or HC (only), both HC and CO. The table shows the incidence of Idle failures only at idle since the vehicles were failed and sent to maintenance only for idle failures.

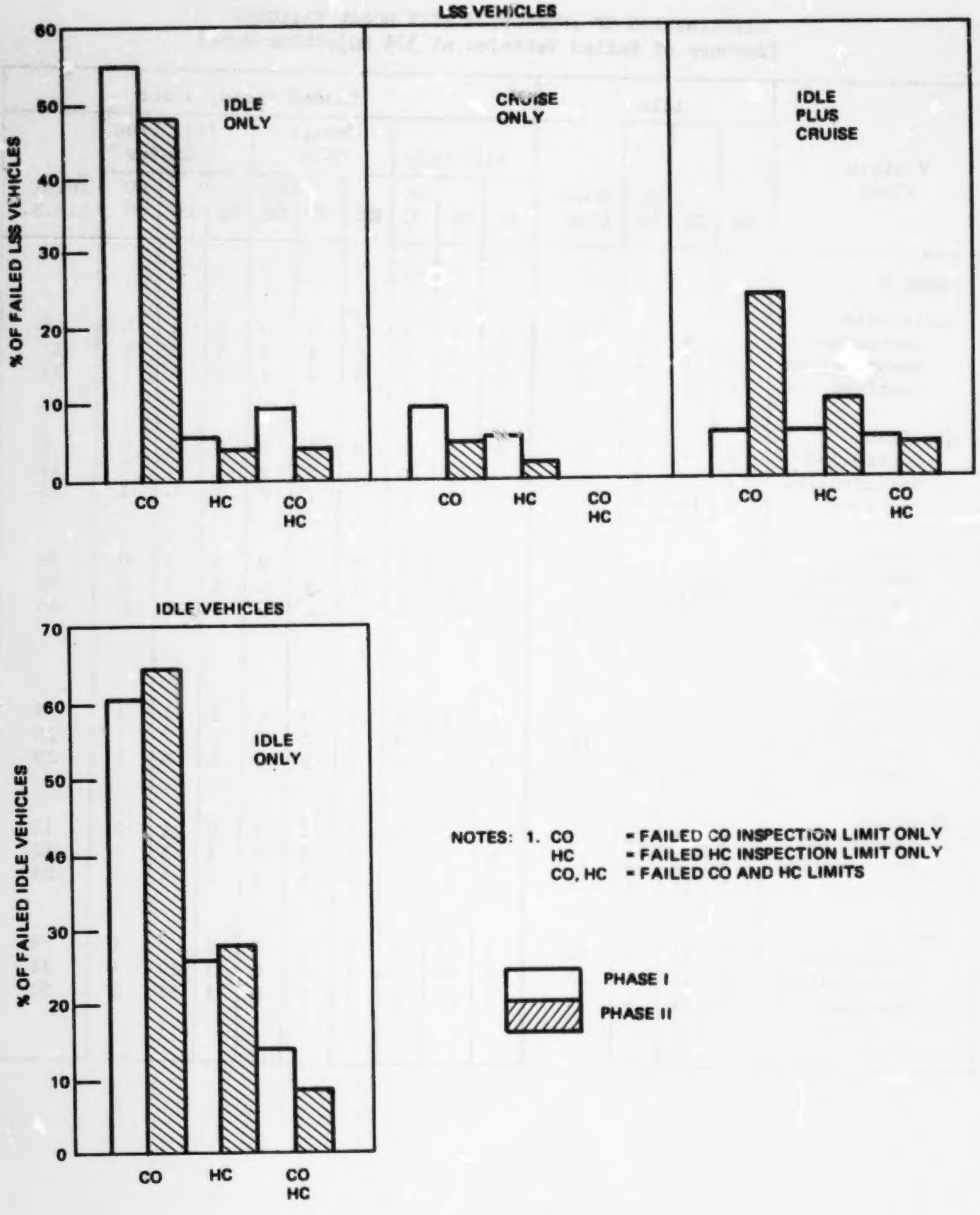
The percent of failed L.S.S. vehicles failing the L.S.S. test because of each pollutant can be calculated from data in Table 3-19. In Michigan for Phase I, 88% of the failed controlled vehicles and 71% of failed uncontrolled vehicles failed only because of idle emissions. In Phase II, 82% of the failed controlled vehicles and 67% of the failed uncontrolled vehicles failed due to idle only. In California, 75% of the failed controlled vehicles but only 46% of the failed uncontrolled vehicles failed only due to idle in Phase I. During Phase II in California 56% of the failed controlled vehicles and only 35% of the failed uncontrolled vehicles failed due to idle only.

Figure 3-8 summarizes the overall Phase I and Phase II Idle and L.S.S. PVIM modal failures. In both Phases, the large majority of failed vehicles had CO related failures in both Idle and L.S.S. regimes. In addition, the L.S.S. regime experienced almost entirely idle or idle plus cruise mode failures. The Idle failure distribution was not significantly different between Phases. The L.S.S. fleet, however, experienced more cruise failures, particularly for CO during Phase II than Phase I. The incidence of only cruise mode failure however was lower in Phase II (7%) than in Phase I (15%) and occured

Table 3-19

DISTRIBUTION OF INSPECTION TEST MODAL FAILURES
(Numbers of Failed Vehicles at 30% Rejection Rate)

Vehicle Fleet	Idle				Loaded Steady State									
					Idle Only			Cruise Only			Idle Plus Cruise			
	HC	CO	HC CO	Total Idle	HC	CO	HC CO	HC	CO	HC CO	HC	CO	HC CO	Total L.S.S.
PHASE I														
California														
Controlled	1	4	2	7	1	4	1	0	0	0	1	1	0	8
Uncontrolled	3	10	2	15	2	3	1	0	3	0	1	2	1	13
Combined	4	14	4	22	3	7	2	0	3	0	2	3	1	21
Michigan														
Controlled	2	7	1	10	0	5	2	0	1	0	0	0	0	8
Uncontrolled	6	7	1	14	0	12	0	3	0	0	1	0	1	17
Combined	8	14	2	24	0	17	2	3	1	0	1	0	1	25
Combined														
Controlled	3	11	3	17	1	9	3	0	1	0	1	1	0	16
Uncontrolled	9	17	3	29	2	15	1	3	3	0	2	2	2	30
Combined	12	28	6	46	3	24	4	3	4	0	3	3	2	46
PHASE II														
California														
Controlled	1	7	0	8	1	4	0	0	0	0	2	1	1	9
Uncontrolled	6	11	2	19	0	7	0	1	2	0	2	7	1	20
Combined	7	18	2	27	1	11	0	1	2	0	4	8	2	29
Michigan														
Controlled	1	9	0	10	1	7	1	0	1	0	0	1	0	11
Uncontrolled	6	5	2	13	0	7	1	0	0	0	1	3	0	12
Combined	7	14	2	23	1	14	2	0	1	0	1	4	0	23
Combined														
Controlled	2	16	0	18	2	11	1	0	1	0	2	2	1	20
Uncontrolled	12	16	4	32	0	14	1	1	2	0	3	10	1	32
Combined	14	32	4	50	2	25	2	1	3	0	5	12	2	52



NOTES: 1. CO - FAILED CO INSPECTION LIMIT ONLY
HC - FAILED HC INSPECTION LIMIT ONLY
CO, HC - FAILED CO AND HC LIMITS

Figure 3-8. Inspection Test Modal Failures

almost entirely for uncontrolled vehicles. A large number of the idle plus cruise mode failures were idle plus low cruise caused by excessively rich idle adjustment. The L.S.S. fleets in both Phases had a total of 20% HC only emission failures for all modes. Many of these failures, however, were due to carburetion problems rather than ignition system component failure.

The Idle vehicles exhibited approximately 63% failure for CO only, 27% failures for HC only and 10% failure for combinations of HC and CO. Most of the Idle failures were also due to carburetion or incorrect idle adjustment.

3.3.2 Diagnosis of Failed Vehicles

A diagnosis of failed vehicles was conducted to determine what type of repair service was required to pass the vehicle. This analysis was conducted independently of the garage diagnosis and repair service actually performed. All exhaust emission and garage diagnostic test data on each car were used during this evaluation. The emission levels generally determined what type of repair was needed to correct the failure. Generally, if HC levels exceeded 1500 ppm, ignition misfire was evident. If HC levels were less than 1500 ppm, the problem was not considered an ignition problem. Using these criteria, the maintenance was divided into carburetion, ignition, and other types of service (valve regrind, overhaul, vacuum leaks). Carburetor service was divided into idle adjustment and carburetor repair or replacement.

Table 3-20 presents the number of vehicles requiring each class of maintenance. Figure 3-9 is a bar chart summary for the Phase I and Phase II data. For the combined L.S.S. and Idle fleet which failed the initial inspection test, 74% in Phase I and 67% in Phase II would have required only an idle adjustment to pass the inspection test. This shows that if a correct diagnosis and idle adjustment had been conducted, about 70% of all failed vehicles would have passed their respective inspection test without any further repair. In general, idle adjustments were sufficient for more Idle vehicles than L.S.S. vehicles.

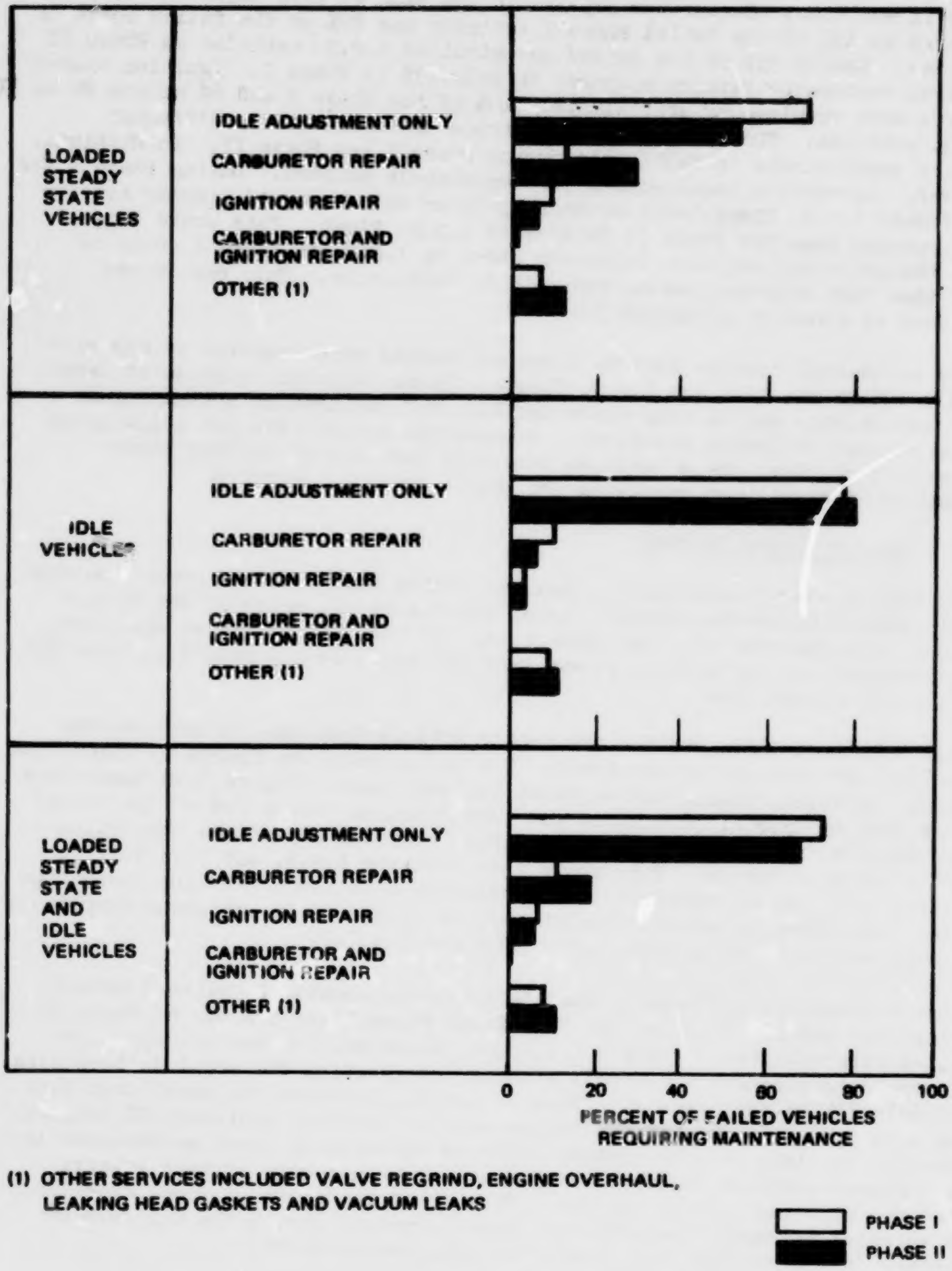
In the Idle fleet, 78% of the Phase I and 80% of the Phase II failed vehicles required only an idle adjustment. Nearly all controlled vehicles (97%) in the Idle fleet required only idle adjustment. The uncontrolled fleet required only idle adjustment in order to pass 69% of both the failed Phase I and Phase II vehicles. Carburetor repairs in addition to idle adjustment were required by 14% of uncontrolled Idle vehicles in both Phases and none of the controlled vehicles. Ignition system repairs were required by only 4% of the Idle vehicles in both Phases. The distribution of service requirements for Idle was relatively uniform in both States and during both Phases suggesting that Idle emission reduction effectiveness should not vary significantly during the program. This result was experienced, as discussed earlier.

In the L.S.S. fleet 70% of the Phase I and 54% of the Phase II failed vehicles required only an idle adjustment. More extensive repairs were required because of the additional failure modes provided by the L.S.S. inspection test. Eighty-one (81%) percent of the failed Phase I controlled L.S.S. vehicles and 70% of the failed Phase II controlled vehicles required only an idle adjustment. The uncontrolled L.S.S. fleet required only an idle adjustment in order to pass 63% of the failed Phase I and 44% of the failed

Table 3-20

DIAGNOSIS OF REPAIRED VEHICLES (30% REJECTION RATE)

Vehicle Fleet	Total Failed Vehicles		Number of Failed Vehicles Requiring									
			Idle Adjustment Only		Carburetor Repair Plus Idle Adjustment		Ignition Repair Plus Idle Adjustment		Carburetor & Ignition Repair Plus Idle Adjustment		Other Mechanical Repairs	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
PHASE I												
California												
Controlled	7	8	6	6	0	1	1	1	0	0	0	0
Uncontrolled	15	13	11	7	3	2	0	2	0	0	1	2
Combined	22	21	17	13	3	3	1	3	0	0	1	2
Michigan												
Controlled	10	8	10	7	0	1	0	0	0	0	0	0
Uncontrolled	14	17	9	12	1	2	1	1	0	1	3	1
Combined	24	25	19	19	1	3	1	1	0	1	3	1
Combined												
Controlled	17	16	16	13	0	2	1	1	0	0	0	0
Uncontrolled	29	30	20	19	4	4	1	3	0	1	4	3
Combined	46	46	36	32	4	6	2	4	0	1	4	3
PHASE II												
California												
Controlled	8	9	8	5	0	2	0	1	0	0	0	1
Uncontrolled	19	20	13	6	3	9	0	1	0	0	3	4
Combined	27	29	21	11	3	11	0	2	0	0	3	5
Michigan												
Controlled	10	11	10	9	0	2	0	0	0	0	0	0
Uncontrolled	13	12	9	8	0	2	2	1	0	0	2	1
Combined	23	23	19	17	0	4	2	1	0	0	2	1
Combined												
Controlled	18	20	18	14	0	4	0	1	0	0	0	1
Uncontrolled	32	32	22	14	3	11	2	2	0	0	5	5
Combined	50	52	40	28	3	15	2	3	0	0	5	6



(1) OTHER SERVICES INCLUDED VALVE REGRIND, ENGINE OVERHAUL, LEAKING HEAD GASKETS AND VACUUM LEAKS

Figure 3-9. Failed Vehicle Diagnosis

Phase II vehicles. Carburetor repairs in addition to idle adjustment were required by 13% of the failed Phase I vehicles and 29% of the failed Phase II vehicles. Nearly 35% of the failed uncontrolled L.S.S. vehicles in Phase II required carburetor repairs compared to only 13% in Phase I. Ignition system repairs were required by approximately 10% of the Phase I and 6% of the Phase II L.S.S. vehicles. The L.S.S. failed vehicles had considerably different service requirements in California during Phase I and Phase II. In Michigan, however, the service requirements were relatively uniform. During Phase I the California L.S.S. fleet had considerably lower emissions and simpler service requirements than the Phase II California L.S.S. Fleet. This would suggest that the potential emission reduction shown by L.S.S. in Phase I would be less than that achieved during Phase II in California. This result was achieved as shown in paragraph 3.2.1.

Major mechanical repairs such as rings and valves were required by approximately 10% of the Idle and L.S.S. fleets. These vehicles received at least idle adjustments and in some cases ignition and carburetion system repair in an attempt to reduce emissions. Because the project did not allow major mechanical repairs, these vehicles generally were exited failing their inspection test without receiving the repair actually required.

3.3.3 Repair Action Summary

Each vehicle that failed its initial inspection test received repair service at a commercial service center. After service it was retested and either passed or failed the emission inspection. If the vehicle failed again and was diagnosed as repairable, it was sent out for a second repair service and retested a second time.

Table 3-21 identifies whether the repair actions that the failed vehicles received were correct or incorrect. The table lists the fleets by inspection regime, location, phase, and emission control class. Figure 3-10 summarizes Table 3-21 by type of inspection and test location. About 89% of the failed Idle vehicles and 81% of the failed L.S.S. vehicles passed the inspection test after maintenance. This shows that both the L.S.S. and Idle service centers had similar capabilities in achieving compliance with the inspection test. Considerable excess cost however, was incurred in achieving compliance as will be discussed in paragraphs 3.3.4 and 3.4.2.2.

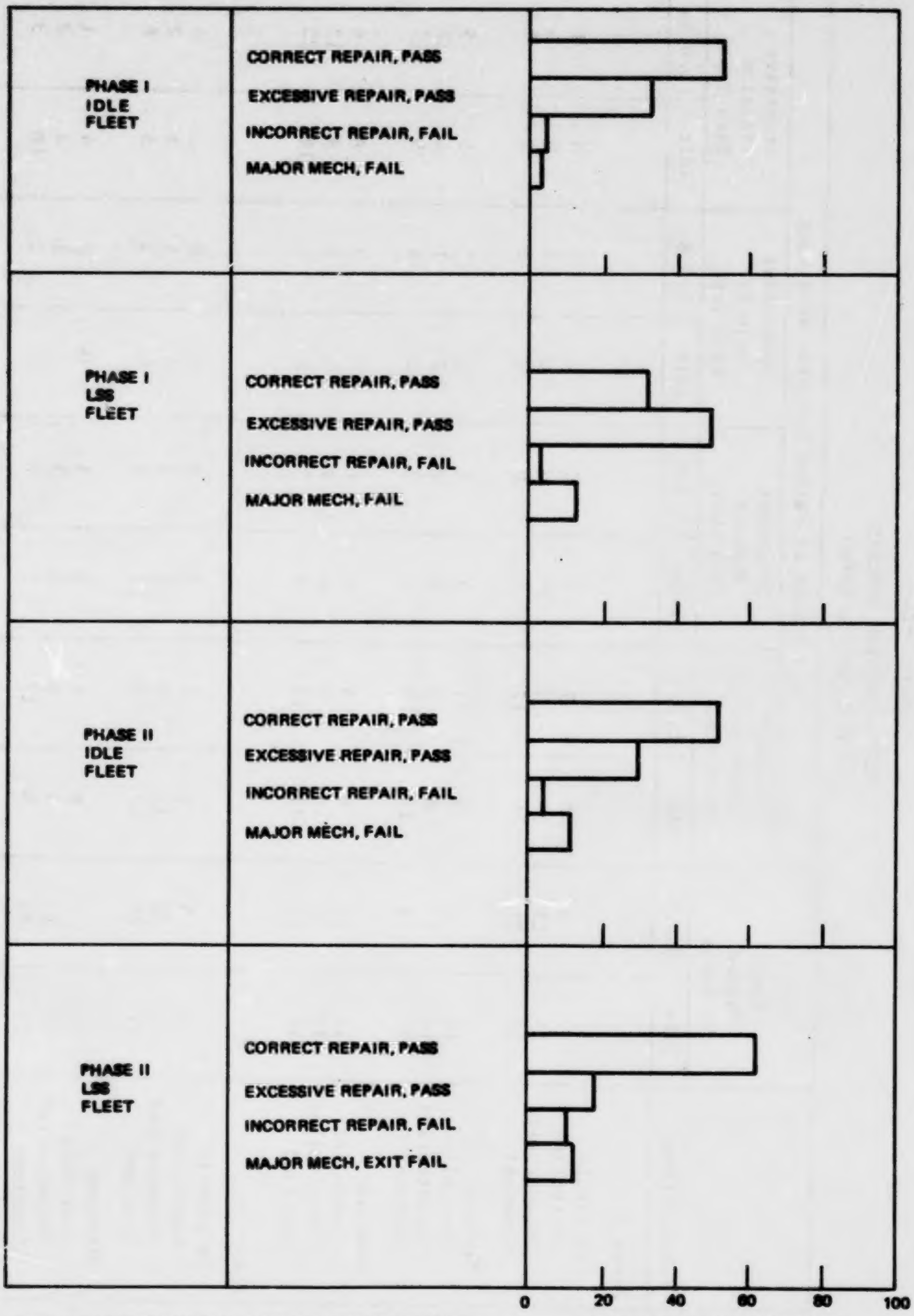
Correct diagnosis and repair, that is achieving compliance without excess effort and expense occurred for 54% of the Phase I and 52% of the Phase II failed Idle vehicles. Phase I L.S.S., in which service centers typically attempted to diagnose and repair without interpreting the modal failure data, had only 33% correct repair. Phase II L.S.S., in which the modal test data was more correctly interpreted by the service centers, achieved 62% correct repair. The Idle service centers achieved essentially equal performance in both Phases although California service centers had more correct repairs than the Michigan service centers. This could be due to previous experience in emission oriented diagnosis and repair acquired during the California Northrop/ARB study and from State licensing requirements.

The performance of the Idle garages did not change significantly from Phase I to Phase II. The performance of the L.S.S. garages, however, was better during

Table 3-21

REPAIR ACTION SUMMARY
(30% Rejection Rate)

Vehicle Fleet	Total Failed Vehicles		Number of Failed Vehicles Receiving							
			Correct Repairs Pass Test		Incorrect Repairs Fail Test		Mechanical Rejects Fail Test		Excessive Repairs Pass Test	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Phase I										
California										
Controlled	7	8	3	7	1	0	0	0	3	1
Uncontrolled	15	13	11	5	0	0	0	3	4	5
Combined	22	21	14	12	1	0	0	3	7	6
Michigan										
Controlled	10	8	3	1	2	0	0	2	5	5
Uncontrolled	14	17	8	2	0	2	2	1	4	12
Combined	24	25	11	3	2	2	2	3	9	17
Combined										
Controlled	17	16	6	8	3	0	0	2	8	6
Uncontrolled	29	30	19	7	0	2	2	4	8	17
Combined	46	46	25	15	3	2	2	6	16	23
Phase II										
California										
Controlled	8	9	6	5	0	0	0	0	2	4
Uncontrolled	19	20	11	10	1	3	4	5	3	2
Combined	27	29	17	15	1	3	4	5	5	6
Michigan										
Controlled	10	11	6	9	0	1	0	0	4	1
Uncontrolled	13	12	3	8	2	1	2	1	6	2
Combined	23	23	9	17	2	2	2	1	10	3
Combined										
Controlled	18	20	12	14	0	1	0	0	6	5
Uncontrolled	32	32	14	18	3	4	6	6	9	4
Combined	50	52	26	32	3	5	6	6	15	9



NOTE: MAJOR MECHANICAL INCLUDED VALVE REGRIND, ENGINE OVERHAUL AND LEAKING HEAD GASKETS

Figure 3-10. Repair Action Summary of Serviced Vehicles

Phase II than during Phase I since more vehicles received correct repair and passed without excessive repairs. More L.S.S. vehicles were exited failing after improper repair during Phase II than Phase I. This was due to one vehicle which received an incorrect idle adjustment and two vehicles which had carburetors rebuilt rather than replacement carburetors installed.

Most of the major mechanical failures were identified and the vehicles exited from the test program after the first service (about 12% of the failed vehicles). In this case, the service center conducted some carburetor and/or ignition service in an attempt to lower the emission levels during the first service. They also diagnosed and commented on the condition of the engine with remarks such as "burned valves" and "needs overhaul." Some vehicles were diagnosed as major mechanical during the second service. In these cases, the major mechanical problems were incorrectly diagnosed by the service center during the first service and the vehicles had received additional repair work in a second attempt to lower emission levels.

Table 3-22 categorizes the service actions actually performed on the serviced vehicles. Data is presented for inspection regime, location, phase and emission control class. The table categorizes the repairs into idle adjustment carburetion and/or ignition repair plus idle and major mechanical repair. No major mechanical repairs were conducted on the serviced vehicles. In some cases, more than one type of repair was performed on a vehicle. These vehicles were categorized by the most appropriate category. Minor parts replacement, such as PC valves, filters, etc., were included in the minor adjustment category. Carburetor work included rebuilding and replacement of carburetors. Ignition work included ignition system components and associated labor. Each serviced vehicle was counted only once. Table 3-22 may be compared to Table 3-21 showing the service actions required.

Except for the Phase I L.S.S. fleet, approximately 50% of the serviced Idle and L.S.S. vehicles received only idle adjustments and minor parts replacement. In the Phase I L.S.S. fleet, only 22% of the serviced vehicles received only idle adjustments. Most L.S.S. vehicles in Phase I received ignition repair (48%) or carburetor plus ignition repair (24%). The incidence of carburetor replacement was relatively low, averaging 5% to 10% of the serviced vehicles, except that no carburetors were replaced in the Phase I Idle fleet while 40% of the serviced L.S.S. vehicles in Phase II had carburetors replacements. Ignition system repair was performed on nearly half of both the Phase I Idle and L.S.S. serviced vehicles. Ignition system repair was performed on approximately one-third of the serviced Phase II Idle vehicles and only 13% of the L.S.S. vehicles. Both ignition and carburetor repairs were performed more frequently on uncontrolled than controlled vehicles.

The decrease in ignition system repair in the Michigan L.S.S. fleet from 68% in Phase I to 9% in Phase II indicates that the proper use of diagnostic data from the Loaded Steady State test can avoid unneeded and excessive repairs. The increase in carburetor repair in the California L.S.S. fleet from 10% in Phase I to 40% in Phase II reflects the ability of the Loaded Steady State test to identify the faulty carburetors correctly.

Table 3-22

SERVICE EVENT SUMMARY (30% REJECTION RATE)

Vehicle Fleet	Total Failed Vehicles		Number of Failed Vehicles Receiving									
			Idle Adjustment Only		Carburetor Repair Plus Idle Adjustment		Ignition Repair Plus Idle Adjustment		Carburetor & Ignition Repair Plus Idle Adjustment		Other Mechanical Repairs	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
PHASE I												
California												
Controlled	7	8	3	5	0	2	4	1	0	0	0	0
Uncontrolled	15	13	9	4	0	0	6	4	0	5	0	0
Combined	22	21	12	9	0	2	10	5	0	5	0	0
Michigan												
Controlled	10	8	5	0	0	0	5	6	0	2	0	0
Uncontrolled	14	17	7	1	0	1	7	11	0	4	0	0
Combined	24	25	12	1	0	1	12	17	0	6	0	0
Combined												
Controlled	17	16	8	5	0	2	9	7	0	2	0	0
Uncontrolled	29	30	16	5	0	1	13	15	0	9	0	0
Combined	46	46	24	10	0	3	22	22	0	11	0	0
PHASE II												
California												
Controlled	8	9	6	4	1	1	1	2	0	2	0	0
Uncontrolled	19	20	9	6	4	10	3	3	3	1	0	0
Combined	27	29	15	10	5	11	4	5	3	3	0	0
Michigan												
Controlled	10	11	6	8	0	1	4	2	0	0	0	0
Uncontrolled	13	12	4	9	1	1	8	0	0	2	0	0
Combined	23	23	10	17	1	2	12	2	0	2	0	0
Combined												
Controlled	18	20	12	12	1	2	5	4	0	2	0	0
Uncontrolled	32	32	13	15	5	11	11	3	3	3	0	0
Combined	50	52	25	27	6	13	16	7	3	5	0	0

3.3.4 Unjustified Repair Action Analysis

As discussed in the previous section, the service centers provided a fair rate of correct diagnosis and repair actions in terms of vehicles passing the second inspection test. However, in several cases the service centers conducted maintenance actions which were in excess of what was actually required to reduce emission levels to pass the inspection test.

Figure 3-11 summarizes the unjustified repairs identified in Table 3-23 separately for Phase I and II. Idle fleet excess repairs were slightly lower in Phase II (43%) than in Phase I (47%). L.S.S. fleet excess repairs, however, decreased significantly from Phase I (65%) to Phase II (23%). The largest source of excess repairs for L.S.S. was in Michigan during Phase I where an 84% excess repair rate was experienced compared to 43% in California. During Phase II, L.S.S. experienced similar excess repair rates in California and Michigan (24% and 22% respectively).

Electrical tune-up repair was evaluated as being the most prominent excess repair action by both Idle and L.S.S. garages. In this group, spark plug replacement was the most common excessive component because HC emission levels were not high enough to be ignition misfire. Excess electrical tune-up was received by 39% of the total failed Idle fleet and 50% of the failed L.S.S. fleet during Phase I. During Phase II, excess electrical tune-ups were received by 28% and 17% for the Idle and L.S.S. fleets. The improved L.S.S. garage performance during Phase II may be partially attributed to improved training as discussed below.

The excess repairs in the Phase I Michigan L.S.S. fleet may in part be attributable to the initial instruction received by the repair centers. OLI staff provided the initial L.S.S. instruction for Phase I in Michigan while Clayton Manufacturing Company personnel provided the initial instruction for the California group. Half-way through Phase I, Clayton reinstructed the Michigan garages on KEY MODE diagnosis and repair. During Phase II, Clayton personnel conducted the KEY MODE instruction to a completely new group of service centers in both California and Michigan. The Phase II instruction was, therefore, probably more correct in stressing the minimum effort to reduce emission, particularly in Michigan as shown by the large decrease in excess repairs (85% to 22%).

Excess ignition system occurred frequently for both Idle and L.S.S. garages. Part of the answer to this high excess electrical tune-up rate may be attributable to past experience and normal practice of the mechanics where spark plugs and other electrical components (rotors, caps, wires and condensers) are often replaced for preventive maintenance or maximum performance.

The excess electrical tune-up rate may also be due to the assumption by mechanics that only ignition misfire can cause excessively high HC emission. It is likely that the initial instructions were not adequate for the mechanic to distinguish ignition misfire from other malfunctions which cause moderately high hydrocarbons such as lean mixtures (lean misfire) or excessively rich mixture (incomplete combustion), and high oil consumption (high blowby).

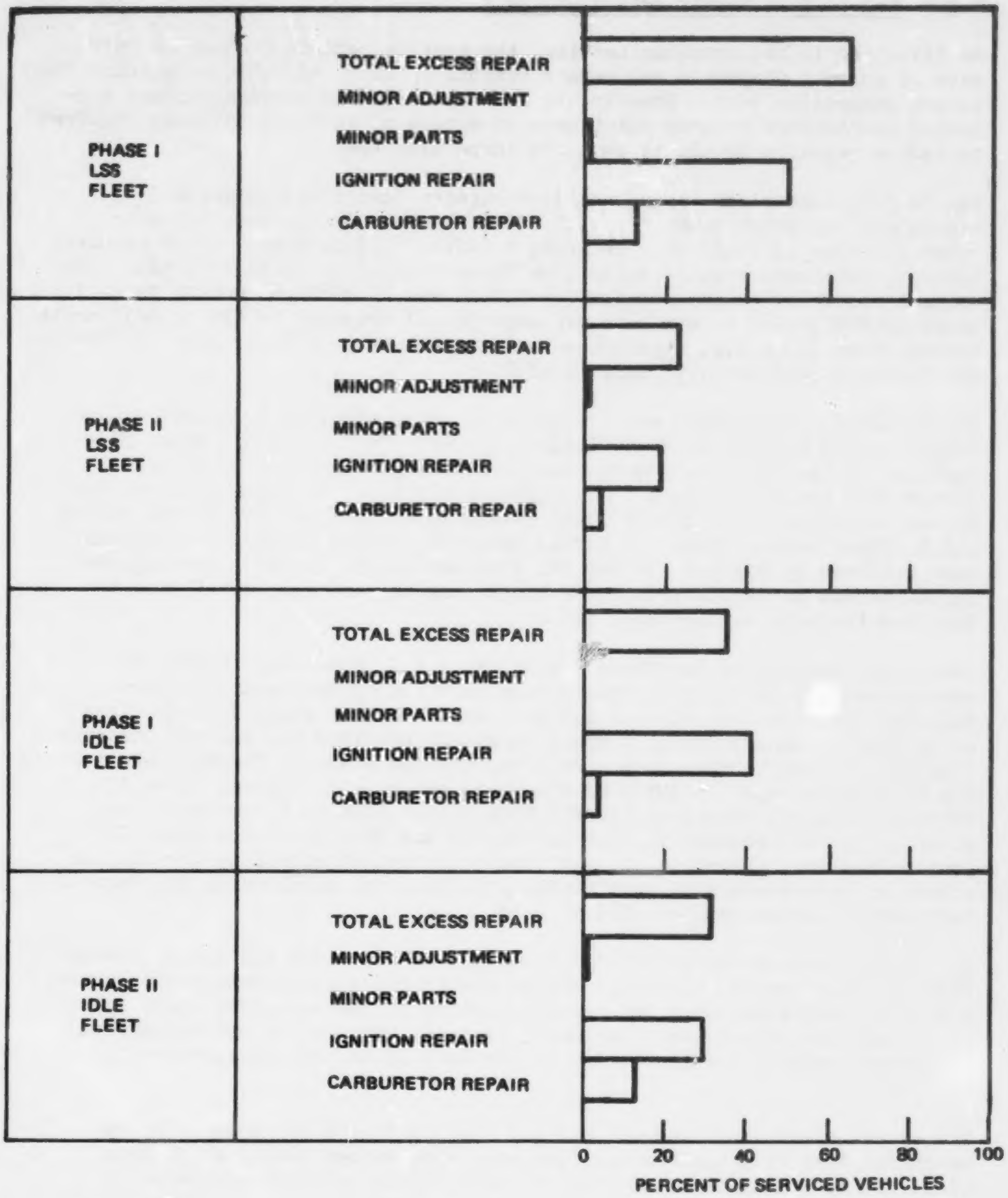


Figure 3-11. Unjustified Repair Actions

Table 3-23

SUMMARY OF UNJUSTIFIED REPAIR (30% Rejection Rate)

Vehicle Fleet	Total Failed Vehicles		Number of Vehicles Receiving Unjustified									
			Minor Adjustment		Minor Parts Replacements		Ignition Repair		Carburetor Repair		Total	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Phase I												
California												
Controlled	7	8	0	0	0	0	3	1	0	1	3	2
Uncontrolled	15	13	0	0	0	1	4	5	0	1	4	7
Combined	22	21	0	0	0	1	7	6	0	2	7	9
Michigan												
Controlled	10	8	0	0	0	0	4	5	0	2	4	7
Uncontrolled	14	17	0	0	0	0	7	12	2	2	9	14
Combined	24	25	0	0	0	0	11	17	2	4	13	21
Combined												
Controlled	17	16	0	0	0	0	7	6	0	3	7	9
Uncontrolled	29	30	0	0	0	1	11	17	2	3	13	21
Combined	46	46	0	0	0	1	18	23	2	6	20	30
Phase II												
California												
Controlled	8	9	0	0	0	0	1	4	1	1	1	5
Uncontrolled	19	20	0	0	0	0	4	1	3	1	7	2
Combined	27	29	0	0	0	0	5	5	4	2	9	7
Michigan												
Controlled	10	11	0	1	0	0	4	1	1	0	5	2
Uncontrolled	13	12	1	0	0	0	5	3	1	0	7	3
Combined	23	23	1	1	0	0	9	4	2	0	12	5
Combined												
Controlled	18	20	0	1	0	0	5	5	2	1	7	7
Uncontrolled	32	32	1	0	0	0	9	4	4	1	14	5
Combined	50	52	1	1	0	0	14	9	6	2	21	12

Excess carburetor service was not generally as much of a problem as was excess electrical repairs. Excess carburetor repairs generally occurred on less than 15% of the serviced vehicles. The few excess carburetor repairs could, however, have a big impact on excess costs.

Excess carburetor replacement or overhaul was performed on 13% of the serviced vehicles in the Phase I L.S.S. group but only on 4% in Phase II. In these cases, the service center had complete truth chart diagnostic information which clearly identified an idle mixture failure only. The truth chart showed that low and high cruise modes of operation were normal and, therefore, that the carburetor main circuits were operating properly. The idle failure problem could have been solved by a correct idle mixture adjustment. The reduced excess repair rate in Phase II again probably reflects the more complete initial instructions. However, the L.S.S. garages neglected to replace some faulty carburetors. Excess carburetor replacement or overhaul in the Idle fleet was performed on 4% and 12% of the serviced cars in Phase I and II respectively.

3.3.5 Failed and Exited Vehicles

The Repair Action Summary in paragraph 3.4.3 showed that several vehicles failed the inspection tests but were exited from the test program. This section summarizes the reasons for this action. Generally, the vehicles in this class can be divided into two groups:

1. Those vehicles which were diagnosed and repaired incorrectly by the repair center.

2. Those vehicles which were diagnosed as requiring major mechanical repair such as valve regrind and engine overhaul.

In both groups the failing vehicle may have been exited after the first or second service. In two cases, the cars were exited before the after service inspection tests were conducted.

Table 3-24 summarizes the various causes that resulted in vehicles not passing the inspection standard. The general causes for failure were carburetion and ignition (both of which are usually repairable), and major mechanical (not repairable due to program restrictions on cost). Ten percent (10%) of the failed vehicles were exited from the program failing their inspection tests in Phase I compared to 13% in Phase II.

Two cars were diagnosed as having induction distribution problems. In this case, lean misfire was diagnosed due to some cylinder probably being lean due to poor mixture distribution and unheated manifolds. Both of these failures occurred at idle and may or may not be correctable by adjustment or carburetor replacement. They were not corrected in this program by either action.

Carburetor idle maladjustment caused 6 vehicles to fail and exit; 4 L.S.S.; 2 Idle. In this case, the idle CO was extremely high with corresponding high HC. All of the cars in this group could have been corrected and passed the inspection test if they had been properly adjusted. Four of these vehicles

Table 3-24

SUMMARY OF FAILED AND EXITED VEHICLES
(30% Rejection Rate)

Vehicle Fleet	Total Failed Vehicles		Number of Vehicles Exited and Failing Because Of									
			Improper Idle Adjustment		Improper Ignition Repair		Improper Carburetor Repair		Major Mechanical Failure		Total	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Phase I												
California												
Controlled	7	8	0	0	0	0	0	0	0	0	0	0
Uncontrolled	15	13	0	0	0	0	1	1	0	1	1	2
Combined	22	21	0	0	0	0	1	1	0	1	1	2
Michigan												
Controlled	10	8	0	1	0	0	0	0	0	1	0	2
Uncontrolled	14	17	0	0	0	1	0	1	2	0	2	2
Combined	24	25	0	1	0	1	0	1	2	1	2	4
Combined												
Controlled	17	16	0	1	0	0	0	0	0	1	0	2
Uncontrolled	29	30	0	0	0	1	1	2	2	1	3	4
Combined	46	46	0	1	0	1	1	2	2	2	3	6
Phase II												
California												
Controlled	8	9	0	0	0	0	0	0	0	0	0	0
Uncontrolled	19	20	2	1	0	0	0	1	2	2	4	2
Combined	27	29	2	1	0	0	0	1	2	2	4	2
Michigan												
Controlled	10	11	0	1	0	0	0	0	0	0	0	1
Uncontrolled	13	12	0	1	2	0	0	0	2	1	4	2
Combined	23	23	0	2	2	0	0	0	2	1	4	3
Combined												
Controlled	18	20	0	1	0	0	0	0	0	0	0	1
Uncontrolled	32	32	2	2	2	0	0	1	4	3	8	4
Combined	50	52	2	3	2	0	0	1	4	3	8	5

had received idle adjustments during second service which were entirely too lean causing lean misfires. These vehicles were exited because the program did not provide for third service.

Four cars should have had their carburetors replaced: 3 L.S.S. and 1 Idle. In the L.S.S. group the cars had failed the low or high cruise modes. The carburetors were either rebuilt incorrectly by the service center or replaced with faulty commercially rebuilt carburetors. The service centers during Phase I were allowed to replace or rebuild carburetors at their discretion. The service centers during Phase II were instructed to replace faulty carburetors with new carburetors because several rebuilt carburetors continued to have excessive emissions in Phase I. Some carburetors which should have been replaced were either very expensive (4 barrel) or oversized for smaller displacement engines in the older vehicles. These carburetors were rebuilt by the mechanics and some of them continued to fail.

The one Idle vehicle which failed because of faulty carburetion had failed the inspection test marginally. At the service center, the vehicle had passed marginally. L.S.S. data on this vehicle (which the service center did not have) indicated carburetor repair or replacement was required because of power mode failures.

Only one car was diagnosed as exiting and failing due to ignition misfire. In this case the car still had ignition misfire after service. It appears this failure should have been corrected. Two cars were diagnosed as failing hydrocarbon limits at idle (CO levels were normal). Both cars were GM vehicles which were originally equipped with full vacuum advance at idle causing the basic timing to advance to about 20° before top center. Experience has shown that with normal idle CO these vehicles still have relatively high idle HC. When the vacuum advance was disconnected (at idle) the idle hydrocarbons dropped considerably. During the test, however, the vacuum advance was connected as originally equipped. Therefore, these two vehicles could not pass the low limits in this program.

The service centers usually conducted correct diagnosis of major mechanical failures, but repaired other systems in hopes of attaining some emission reduction. Two cars were diagnosed as requiring head gasket replacement. This failure caused cylinder(s) to leak unburned fuel or combustion products to other cylinders causing excess emissions. Valve regrind was required on 5 vehicles where one or two cylinders had low compression. Seven (7) vehicles were diagnosed as requiring a complete engine overhaul (rings plus valve regrind).

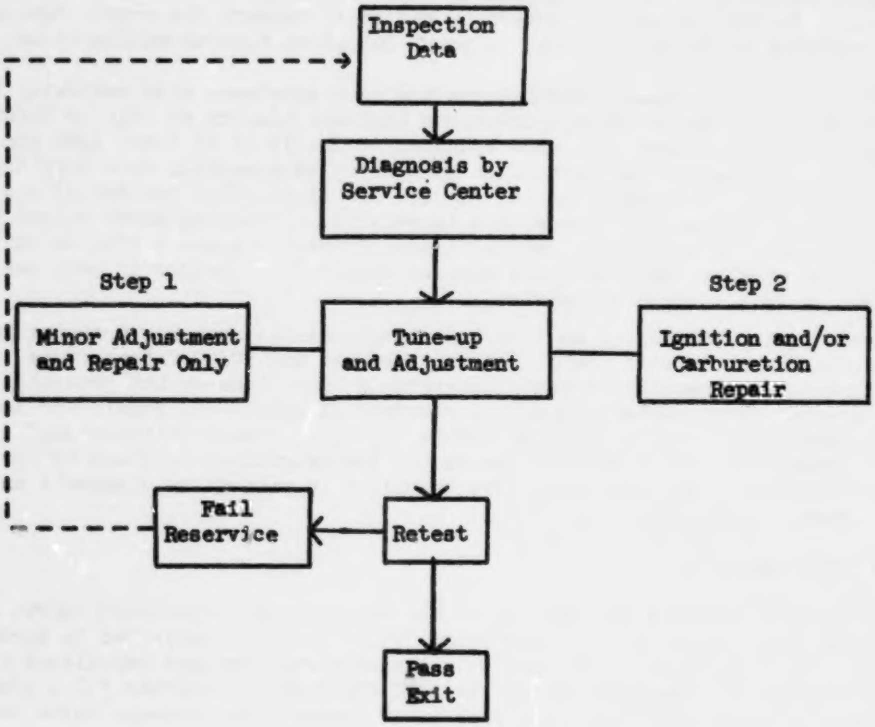
In summary, almost half of the failed and exited vehicles could have been repaired, often by applying good adjustment techniques. It was apparent from this analysis that the mechanics should have received more complete instructions in idle adjustment techniques for attaining low emissions and maintaining good idle performance while still avoiding lean misfire. Those vehicles which could not be repaired without very high cost or which were not repairable due to inherent design (poor induction distribution) constituted 2% of all vehicles or 7% of the failed vehicles.

3.3.6 Revised Maintenance Procedure Recommendation

In the Short Cycle Project the procedures for diagnosis and maintenance action were inadequate in some respects. These were discussed in the preceding analysis where the diagnosis of the failed vehicles identified different required repair actions than those actually performed on the vehicles. Many vehicles received unjustified or excessive repairs. These observations indicated that the mechanic was not always sure of the minimum correct repair action to lower the vehicle's emissions.

The KEY MODE procedure stressed repair function in accordance with the results of the "truth chart" diagnostic data. Final adjustments were then conducted following the repair action. The Idle inspection procedures stressed the minor adjustments as a first step. If the minor adjustment step did not cure the problem, repair actions (electrical or carburetion) were conducted as required by the idle emission (only) information supplied to the garage.

3.3.6.1 Suggested Procedure - In view of the problems outlined in Section 3.3, it appears that the maintenance procedures used in future programs might best be applied to the failing vehicles if the following general steps are used:


Inspection Data
Diagnosis by Service Center
Step 1
Minor Adjustment and Repair Only
Tune-up and Adjustment
Step 2
Ignition and/or Carburetion Repair
Fail Reservice
Retest
Pass Exit

After receiving the inspection data, the mechanic would conduct the diagnosis and determine whether the vehicle should receive only minor adjustment (and minor repair) such as idle mixture, timing and dwell or whether it should receive a major tune-up (ignition and/or carburetion) including final adjustments.

The diagnostic data may indicate that only idle mixture adjustment would be required to pass the inspection test. During the minor adjustment (Step 1), the mechanic would adjust the applicable items to manufacturers specifications. He would then readjust the idle mixture and speed. If the diagnostic data indicated an ignition misfire, the mechanic would repair or replace ignition components to correct the misfire (Step 2). Following the repair function, the mechanic would then conduct the applicable minor adjustments. Similarly, if the diagnostic data indicated power mode carburetion problems the mechanic would replace or repair the carburetor (Step 2) and then conduct the applicable minor adjustments.

This approach should minimize the excess repairs by conducting only the adjustments necessary to pass the inspection test. Table 3-25 shows the suggested procedure which follows the above approach.

3.3.6.2 Implementation Philosophy - To implement this approach, a set of general criteria to aid the garage mechanic in diagnosis and repair is required. He must accurately determine and carry through the repair action. The criteria in Table 3-25 readily point out gross tune-up malfunctions.

Generally, gross tune-up malfunctions are very prominent when reviewing inspection data. For example, continuous ignition misfire at idle or light loads at higher speeds will show hydrocarbon levels of at least 1500 ppm or greater. Malfunctioning carburetor main circuits generally show very high CO levels when compared to normal carburetors (i.e., they are definitely "broken"). Plugged air bleeds, and inoperative or leaking power valves are common causes of carburetor malfunctions. Correct diagnosis will definitely determine whether the carburetor must be repaired or whether it only requires an idle mixture adjustment.

Successful implementation must include comprehensive mechanic training in accurate diagnosis with the aid of osciloscopes and HC/CO infrared gas analyzers. The mechanic already understands basic tune-up but generally lacks experience and techniques for accurate diagnosis and repair for low emissions. Appropriate training should emphasize "hands on training." Past experience has shown that instructor demonstrations followed by mechanic participation is the most effective technique in presenting diagnosis and adjustment techniques.

3.4 COST ANALYSIS

This section presents the results of the analysis of inspection program and vehicle maintenance costs of servicing failed vehicles described in paragraph 2.3.5. The maintenance cost analysis included fuel savings calculated from fuel consumption measured during the 1972 CVS test. Paragraph 3.3.1 presents inspection program costs. Paragraph 3.4.2 presents maintenance costs including

Table 3-25

SUGGESTED DIAGNOSIS AND MAINTENANCE PROCEDURE

Diagnosis at Service Center

- Connect scope and calibrate HC/CO instrument.
- Check CO and HC at 2500 rpm neutral with air filter installed.
- Measure total advance.
- Check idle CO and HC with air filter installed.
- Measure basic timing and dwell, check scope pattern for misfire.
- Remove air filter and recheck 2500 rpm and idle emissions.
- Conduct "power balance" test (weak cylinders).
- Diagnose for:

  Dirty air filter (replace if CO with filter is more than 1% higher than without filter).

  Main carburetor circuit malfunction (power valve or incorrect fuel bowl levels).

  Vacuum leaks.

  High idle emissions.

  Ignition misfire (plugs or wires).

  Malfunctioning advance systems, incorrect dwell and basic timing.

  High blowby, rings, or valve regrind.

Dispatch Vehicle for Repair Service

- Step 1, minor adjustment and repair only.
- Step 2, tune-up and adjustment.

Table 3-25 (Continued)

SUGGESTED DIAGNOSIS AND MAINTENANCE PROCEDURE

Step 1 - Minor Adjustment and Minor Repair (only)

- Conduct minor repairs.
- Set dwell to specifications.
- Reset basic timing to specifications.
- Check PCV system.
- Adjust idle CO and speed simultaneously to prescribed levels.
- Install air cleaner element (new if diagnosis requires) and recheck emission levels.

Step 2 - Tune-Up (Ignition)

- Install points, plugs, condenser, and/or plug wires to correct ignition misfire.
- Repair other diagnosed malfunctioning items such as PCV, vacuum advance control systems.
- Complete ignition tune-up step by conducting the minor adjustments outlined in Step 1.

Step 2 - Tune-Up (Carburetion)

- Remove carburetor and repair or replace (as per program instructions).
- Reinstall and check CO emissions in the main circuit (2500 RPM unloaded or high cruise road load).
- Compare carburetor main circuit CO emissions to the initial diagnostic data. If emissions are within limits, proceed. If not, rediagnose and repair as described in the program.
- Complete carburetor tune-up step by conducting the minor adjustments outlined in Step 1.

an anlysis of excess repair costs derived from the maintenance analysis conducted in Section 3.3. Paragraph 3.4.3 summarizes total inspection and maintenance program costs.

3.4.1 Inspection Program Costs

The inspection program costs for California and Michigan are presented in Table 3-26. Investment costs were about 68% higher for L.L.S. than Idle. Operating costs for the two regimes were very close. These estimates were based on a state operated inspection program in California inspecting all passenger vehicles once each year. Although total costs appear fairly high, the cost per vehicle is relatively low, approximately $2.21 for Idle and $3.07 for L.S.S. This fee in the first year would pay for capital equipment, facilities, and program start-up costs as well as first year operation. Thereafter, an annual charge of about $1.00 bor both Idle and L.S.S. would pay for operating and maintenance costs subject to inflationary rises. If the capital investment costs were amortized at 6% for 10 years (state bonds), the annual cost during the 10 years would be reduced to $1.16 for Idle and $1.35 for L.S.S. This fee could be collected as part of the vehicle registration and licensing process and is relatively small in comparison to both the maintenance cost and the present annual vehicle registration fees charged in most states.

It should be emphasized that an economic evaluation of inspection programs was not part of this study and that the cost per vehicle developed for a previous California PVIM study (Reference 1) was applied to Michigan. Several assumptions utilized in the California study may not be valid in Michigan; therefore, the cost estimate in California may be lower than that which would be experienced in Michigan. The three principal assumptions were that: (1) the test centers would operate at uniform efficiency during all parts of the year with a steady waiting line of vehicle; and (2) that failed vehicles would not be retested after service.

The first assumption may be invalid due to winter storms in which vehicle owners are unable to reach the inspection center. As many as 20% of the test days may be lost in this manner. Therefore, additional inspection centers would have to be built and staffed to account for those vehicles that were not tested during those 20% of operating days. This would result in approximately a 25% increase in operating and capital investment costs.

The second assumption was that retest after maintenance would not be required. Additional cost would depend upon the rejection rate experienced if retest was required. At a hypothetical 50% rejection rate, a 50% increase in test capacity, i.e., investment and operation would be required. The compounding of these two factors would nearly double costs raising the first year cost per vehicle in Michigan to $4.14 for Idle and $5.76 for L.S.S. The corresponding cost, assuming capital costs are amortized for 10 years, would be $2.18 for Idle and $2.53 for L.S.S. However, if a program was conducted at a rejection rate of 20%, a 20% increase in test capacity would be required. The compounding of additional capacity for weather downtime and retest (1.25 x 1.20) would then represent a 50% increase in cost over the California

Table 3-26

INSPECTION PROGRAM COSTS [1]

State or Single Contractor Operated

COST ELEMENT	CALIFORNIA[2]		MICHIGAN[3]	
	Idle	L.S.S.	Idle	L.S.S.
INVESTMENT COSTS				
Present Cost	$12,084,000	$19,830,000	$ 6,646,000	$10,907,000
Amortized - 10 Years at 6%	$ 1,610,000	$ 2,642,000	$ 885,000	$ 1,453,000
Cost per Vehicle[2]	$1.21	$1.98	$1.21	$1.98
Amortized - 10 Years at 6%[2]	$ .16	$ .26	$ .16	$ .26
OPERATING COSTS				
Total First Year	$ 9,978,000	$10,919,000	$ 5,500,000	$ 5,995,000
Cost per Vehicle[2]	$1.00	$1.09	$1.00	$1.09
TOTAL INVESTMENT AND OPERATING COST				
Total First Year	$22,062,000	$30,749,000	$12,146,000	$16,902,000
Cost per Vehicle[2]	$2.21	$3.07	$2.21	$3.07
Total Amortized	$11,588,000	$13,561,000	$ 6,385,000	$ 7,448,000
Cost per Vehicle[2]	$1.16	$1.35	$1.16	$1.35

1. Retest after maintenance not included.

2. Reference 1.

3. Assumes 5.5 million vehicles in Michigan based on 1971 vehicle registration data.

study. This would result in initial cost per vehicle of $2.32 for Idle and $4.61 for L.S.S. or an amortized cost per vehicle of $1.74 for Idle and $2.54 for L.S.S.

3.4.2 Maintenance Cost Analysis

Maintenance costs were analyzed to identify primary cost elements, cost of additional service, and the cost of excessive (unjustified) repair actions.

3.4.2.1 Average Serviced Vehicle Costs

Table 3-27 presents a summary of average total service costs for each phase of the Short Cycle Project showing the actual repair cost for the serviced vehicles and the cost less excessive repair costs. Phase I and II serviced vehicle costs agreed well for the Idle fleets in both cities and the L.S.S. fleet in California. The Michigan L.S.S. fleet, however, experienced considerably lower cost during Phase II than Phase I. From Table 3-27, it can be seen that Idle service was least costly in all situations except Phase II, Michigan, in which L.S.S. was least costly. Average repair costs were $29 for Idle and $34 for L.S.S. The highest total service repair cost was $41.04 per serviced L.S.S. vehicle during Phase I in Michigan. The lowest cost per serviced vehicle ($22.34) was in the Michigan L.S.S. fleet during Phase II. Costs for repairing controlled vehicles were typically $7 to $8 less than for uncontrolled vehicles. Table 3-28 shows the corresponding fleet average service repair costs.

Figures 3-12 and 3-13 show the percent frequency of repair cost for Phase II only. Phase II only was selected because of the excess maintenance occurring in Phase I. The plots show the percent of serviced vehicles with service costs in $10 increments. Figure 3-12 (California) may be considered representative of realistic cost distributions in a program which has fairly high emission levels coupled with stringent standards. Figure 3-13 (Michigan) may be considered representative of a program with primarily idle failures.

In California, Figure 3-12 shows that the most common repair cost for both Idle and L.S.S. was between $10 and $20 which was incurred by 48% of vehicle owners in the Idle program and 28% of the vehicle owners in the L.S.S. program. Idle and L.S.S. experienced repair costs in excess of $60 for 12% and 23% of the vehicle owners respectively. Approximately 75% of the Idle vehicles were repaired for less than $40, compared to 68% of the L.S.S. vehicles. Idle and L.S.S. exhibited similar cost distributions on uncontrolled vehicles, however, for controlled vehicles, the maximum Idle maintenance cost was below $40 while 10% of the L.S.S. costs exceeded $100.

In Michigan, Figure 3-13 shows that the most common repair cost was between $20 and $30 for the Idle vehicles and was incurred by 40% of the vehicle owners in the Idle program. The most common repair cost was between $10 and $20 for the L.S.S. vehicle and was incurred by 48% of the vehicle owners in the L.S.S. program. Ninety-six percent (96%) of the L.S.S. vehicles were repaired for less than $40 compared to 88% of the Idle vehicles. Idle and L.S.S. repair cost distributions were similar for controlled vehicles although L.S.S. tended to have a lower cost distribution than Idle for uncontrolled vehicles.

Table 3-27
SERVICE COST AVERAGED OVER SERVICED VEHICLES ONLY - ALL SERVICE ACTIONS
(30% Rejection Rate)

Cost/Phase	California		Michigan		Combined	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
COSTS AS INCURRED						
Phase I						
Controlled	28.12	20.91	28.16	43.81	28.16	32.39
Uncontrolled	25.30	38.42	26.69	39.73	25.97	39.16
Combined	26.20	31.77	27.30	41.04	26.78	36.81
Phase II						
Controlled	19.58	33.52	24.77	18.40	22.46	25.20
Uncontrolled	37.81	39.90	33.43	25.96	36.03	34.67
Combined	32.41	37.92	29.66	22.34	31.14	31.03
LESS EXCESS COSTS						
Phase I						
Controlled	18.58	18.38	19.02	25.60	18.84	21.99
Uncontrolled	16.94	33.81	17.35	23.99	17.14	28.25
Combined	17.46	27.93	18.05	24.51	17.77	26.07
Phase II						
Controlled	13.56	25.30	19.77	17.58	17.01	20.74
Uncontrolled	24.77	35.29	21.44	23.56	23.42	30.89
Combined	21.45	32.19	20.71	20.70	21.11	27.11

3.4.2.2 Excess Repair Costs

Tables 3-28 and 3-29 present the estimated costs for repair actions which were expected to be effective in reducing emissions. Work was identified as excessive if it would not have been expected to reduce emissions. The criteria for excess repairs is described more fully in paragraph 2.3.4.

In general, Idle and L.S.S. exhibited considerable excessive repair costs. For the combined phases 33% of the average repair cost for Idle was excessive, while 19% of the average repair cost for L.S.S. was excessive. Table 3-29 presents the percent of total service cost judged as excessive. The results of the combined phases and states are typical of results achieved in each Idle regime subfleet. L.S.S. excess repair cost was 26% in Phase I compared to 11% in Phase II.

Table 3-28

SERVICE COST AVERAGED OVER ALL VEHICLES - ALL SERVICE ACTIONS
(30% Rejection Rate)

Cost/Phase	California		Michigan		Combined	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
COST AS INCURRED						
Phase I						
Controlled	5.62	4.41	7.82	10.31	6.72	7.36
Uncontrolled	9.49	13.50	9.83	16.88	9.66	15.19
Combined	7.68	8.90	8.85	13.86	8.27	11.38
Phase II						
Controlled	4.48	8.15	7.08	5.62	5.78	6.89
Uncontrolled	18.31	21.00	10.87	7.99	14.59	14.50
Combined	11.86	14.66	9.10	6.85	11.37	10.76
LESS EXCESS COST						
Phase I						
Controlled	3.72	3.87	5.28	6.02	4.50	4.95
Uncontrolled	6.35	11.87	6.39	10.20	6.37	11.04
Combined	5.12	7.12	5.85	8.28	5.49	8.00
Phase II						
Controlled	3.10	6.15	5.65	5.37	4.38	5.76
Uncontrolled	11.77	18.58	6.97	7.25	9.37	12.92
Combined	7.72	12.45	6.35	6.35	7.04	9.40

Table 3-29

PERCENT OF REPAIR COST WHICH WAS EXCESSIVE
(30% Rejection Rate)

Vehicle Fleet	California		Michigan		Combined	
	Idle	Key Mode	Idle	Key Mode	Idle	Key Mode
Phase I						
Controlled	33.9	12.3	32.5	41.6	33.2	27.0
Uncontrolled	33.0	12.0	35.0	40.0	34.0	26.0
Combined	33.3	12.1	33.9	40.3	33.6	26.2
Phase II						
Controlled	30.8	24.5	20.2	4.4	25.5	14.5
Uncontrolled	35.7	11.5	35.9	9.2	35.8	10.4
Combined	34.9	15.1	30.2	7.3	32.6	11.2

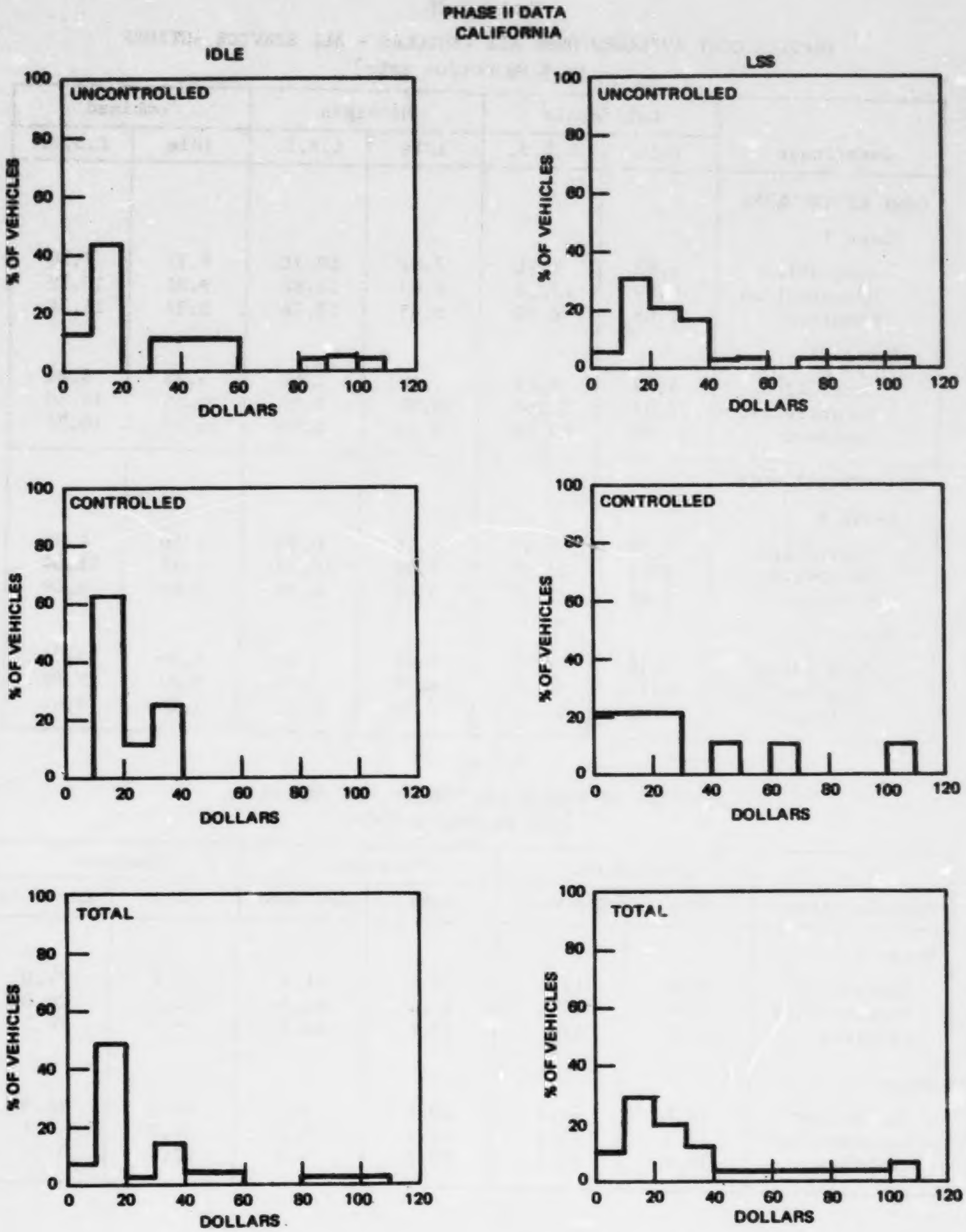


Figure 3-12. Distribution of Average Repair Cost Per Repaired Vehicle

PHASE II DATA
MICHIGAN

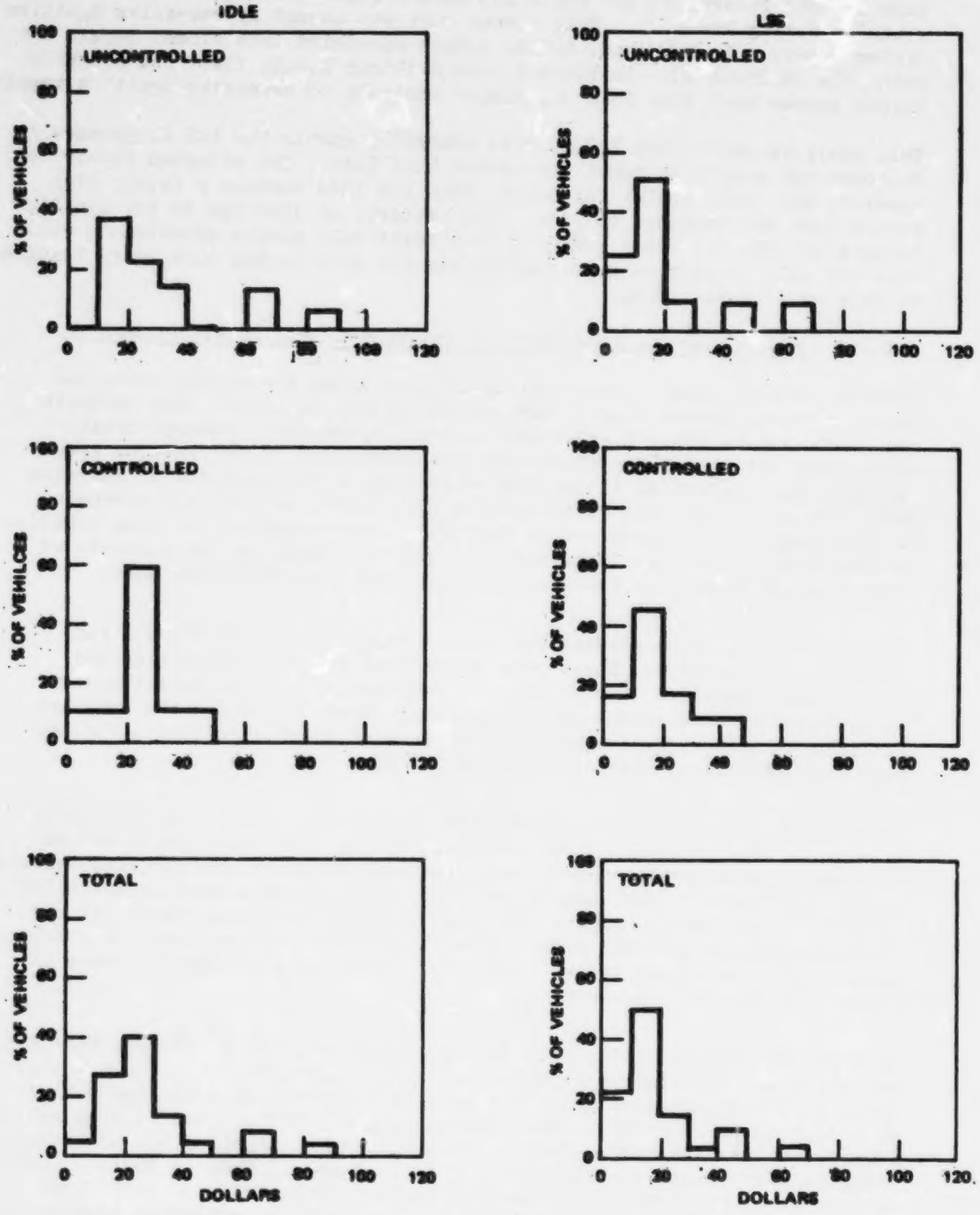


Figure 3-13. Distribution of Average Repair Cost per Repaired Vehicle

In California, the rate of excess repair by L.S.S. was one-half less than by Idle in both Phases, except for a 25% excess repair cost for controlled vehicles during Phase II. This excess cost was caused by excessive ignition system repair. In Michigan, L.S.S. showed one-third less excess repair cost than Idle in Phase II. In Phase I, the Michigan L.S.S. fleet had slightly higher excess cost than Idle due almost entirely to excessive ignition repairs.

This analysis shows that L.S.S. data generally enable the L.S.S. garages to diagnose and repair malfunctions better than Idle. The adjusted repair cost, however, was still higher for L.S.S. than for Idle because a fairly high excess cost was assigned to Idle. The criteria of 1500 ppm HC for ignition failure and the OLI staff judgment that relatively simple adjustments would pass the idle inspection were responsible for this excess cost being assigned to Idle as well as L.S.S.

3.4.2.3 Repair Cost as a Function of Inspection Test Rejection Rate

Average vehicle repair costs were calculated using the actual costs and costs deleting excess repairs for several rejection rates. The analysis was performed on Phase I and Phase II data separately. Average repair costs were calculated for those vehicles identified as failing the recommended L.S.S. rejection limits that were used in the analysis of Emission Reduction as a Function of Inspection Test Rejection Rate and presented in paragraph 3.2.3. These costs, therefore, were based on the same vehicles as the effectiveness analysis and provided cost data for the analysis of Cost Effectiveness as a Function of Inspection Test Rejection Rate.

Figures 3-14 and 3-15 present the actual repair costs for Phase I and Phase II respectively. Costs were calculated for both controlled and uncontrolled vehicles. Costs for all vehicles as well as only the serviced vehicles were calculated. The total repair costs for the vehicles included in each rejected population were used in this analysis, whether they were associated with an HC or CO failure.

In Phase I (Figure 3-14), Idle was less costly than L.S.S. at all rejection rates for both controlled and uncontrolled vehicles. There was no difference between Idle repair costs for controlled or uncontrolled vehicles. L.S.S. was slightly less costly for controlled vehicles than uncontrolled vehicles. The highest repair costs per serviced vehicle occurred at the lowest rejection rate and decreased with increasing rejection rate. Idle repair costs decreased faster than L.S.S. costs as the rejection rate of controlled vehicles increased.

In Phase II (Figure 3-15), Idle service costs were about 20% less than L.S.S. service costs for controlled vehicles at all rejection rates. L.S.S. service costs were slightly less than Idle service costs for uncontrolled vehicles at rejection rates greater than 25% and slightly higher than Idle at rejection rates less than 20%. Repair costs for both controlled and uncontrolled vehicles were closer for Idle and L.S.S. in Phase II than in Phase I. Idle service costs were about the same for controlled vehicles in each Phase but considerably higher for controlled vehicles during Phase II than during Phase I. L.S.S. service costs were slightly lower in Phase II than in Phase I for both controlled and uncontrolled vehicles.

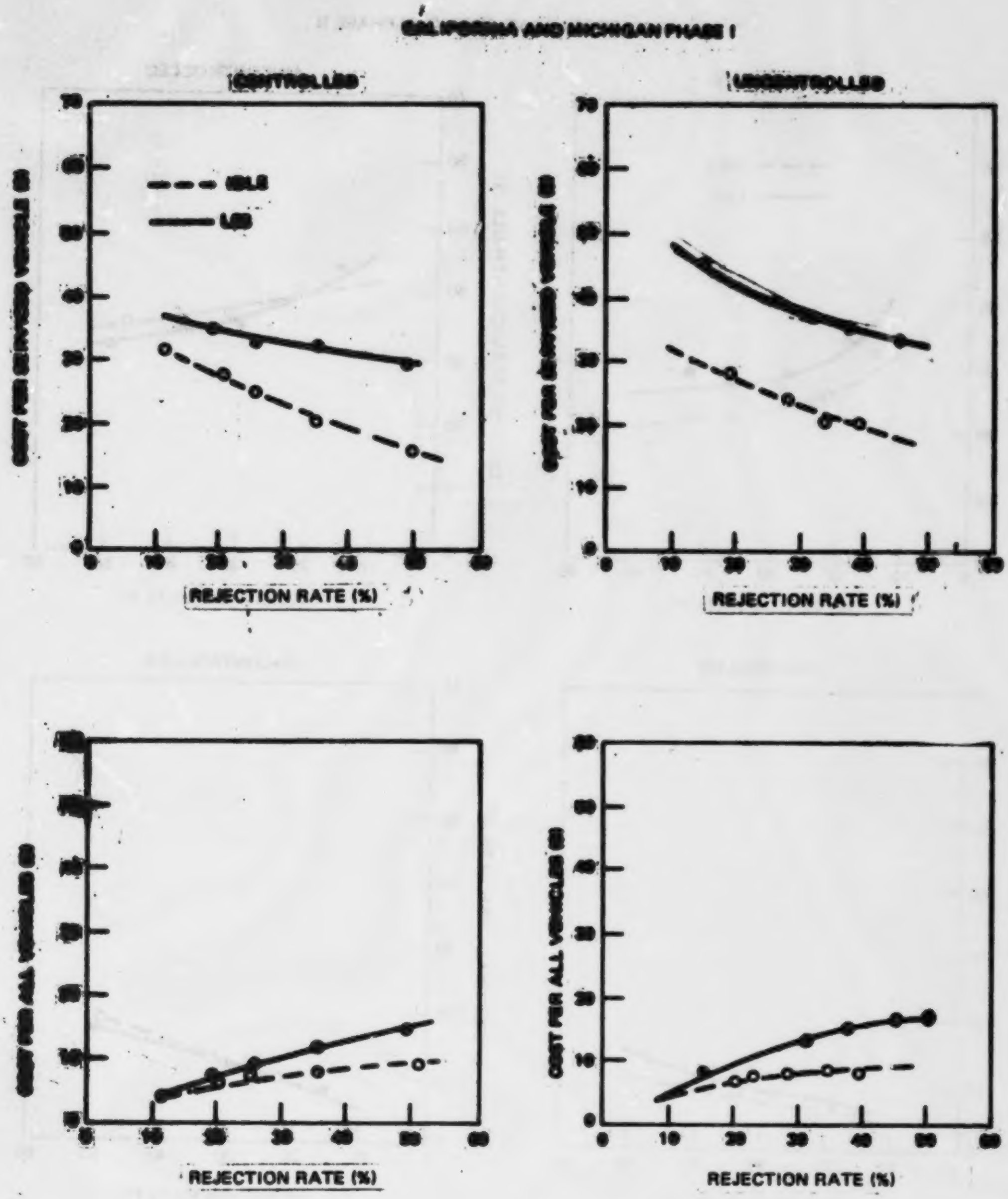


Figure 3-14. Average Vehicle Repair Costs – Phase I

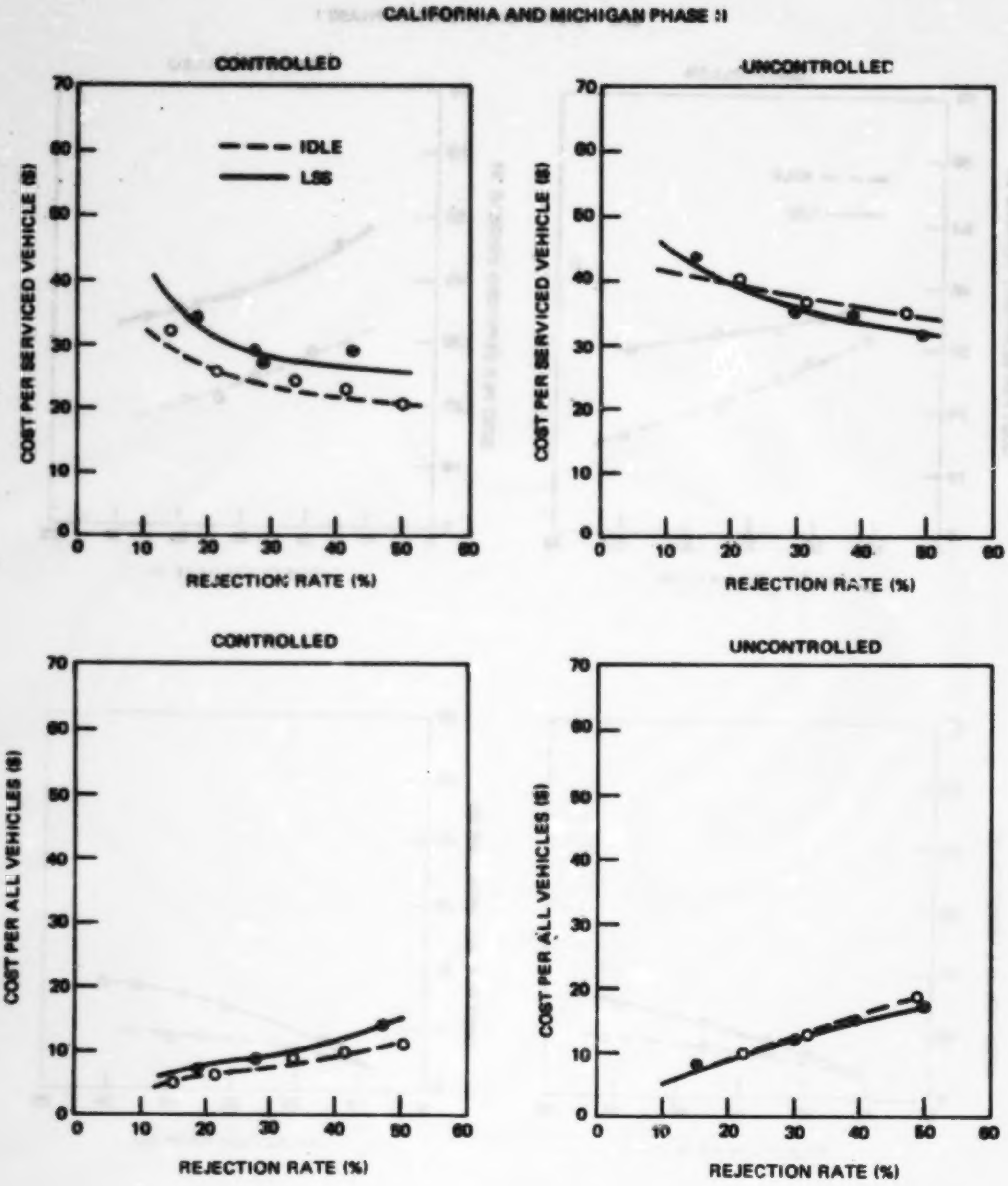


Figure 3-15. Average Vehicle Repair Cost – Phase II

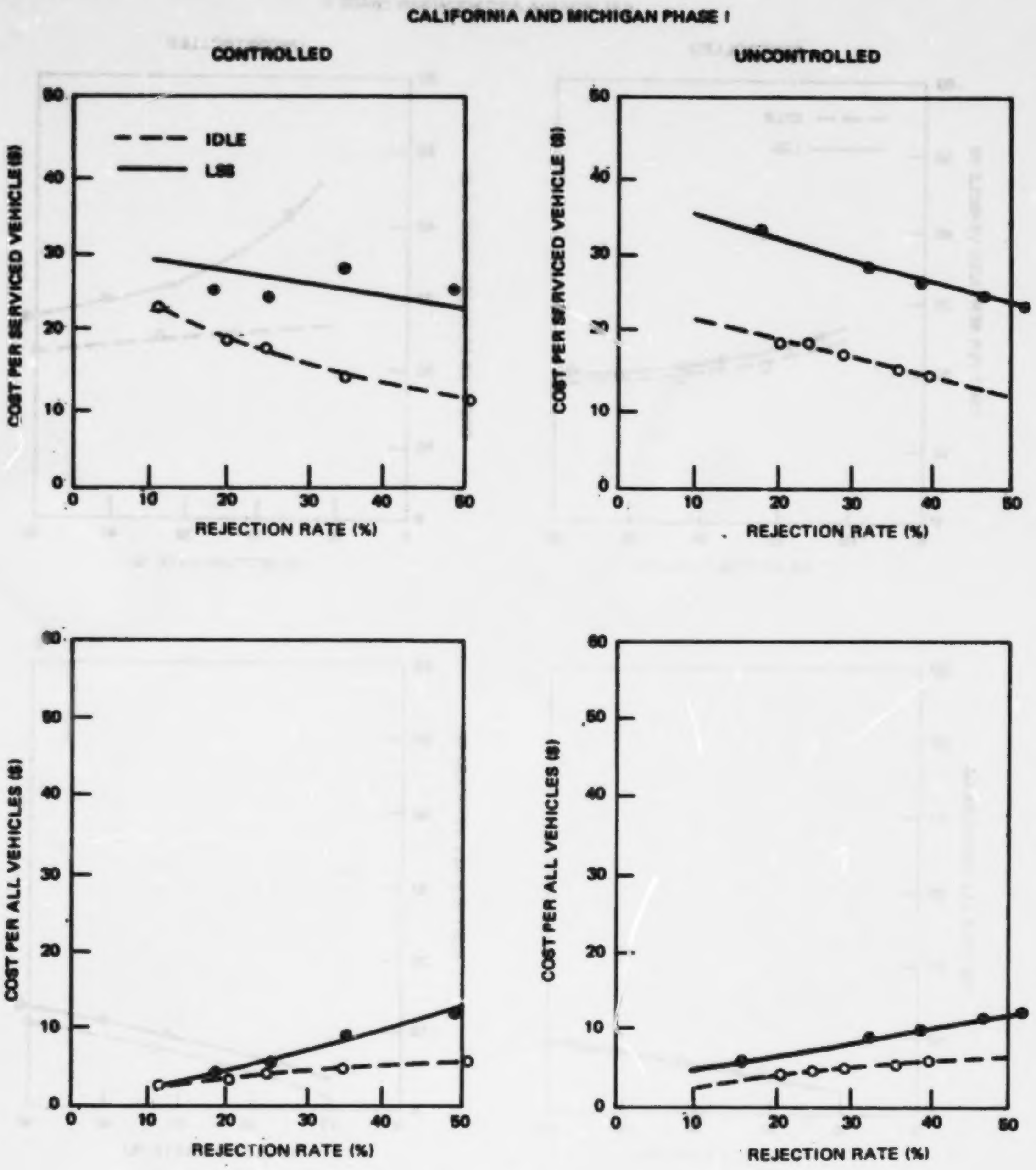


Figure 3-16. Average Vehicle Repair Costs Less Excess Repairs – Phase I

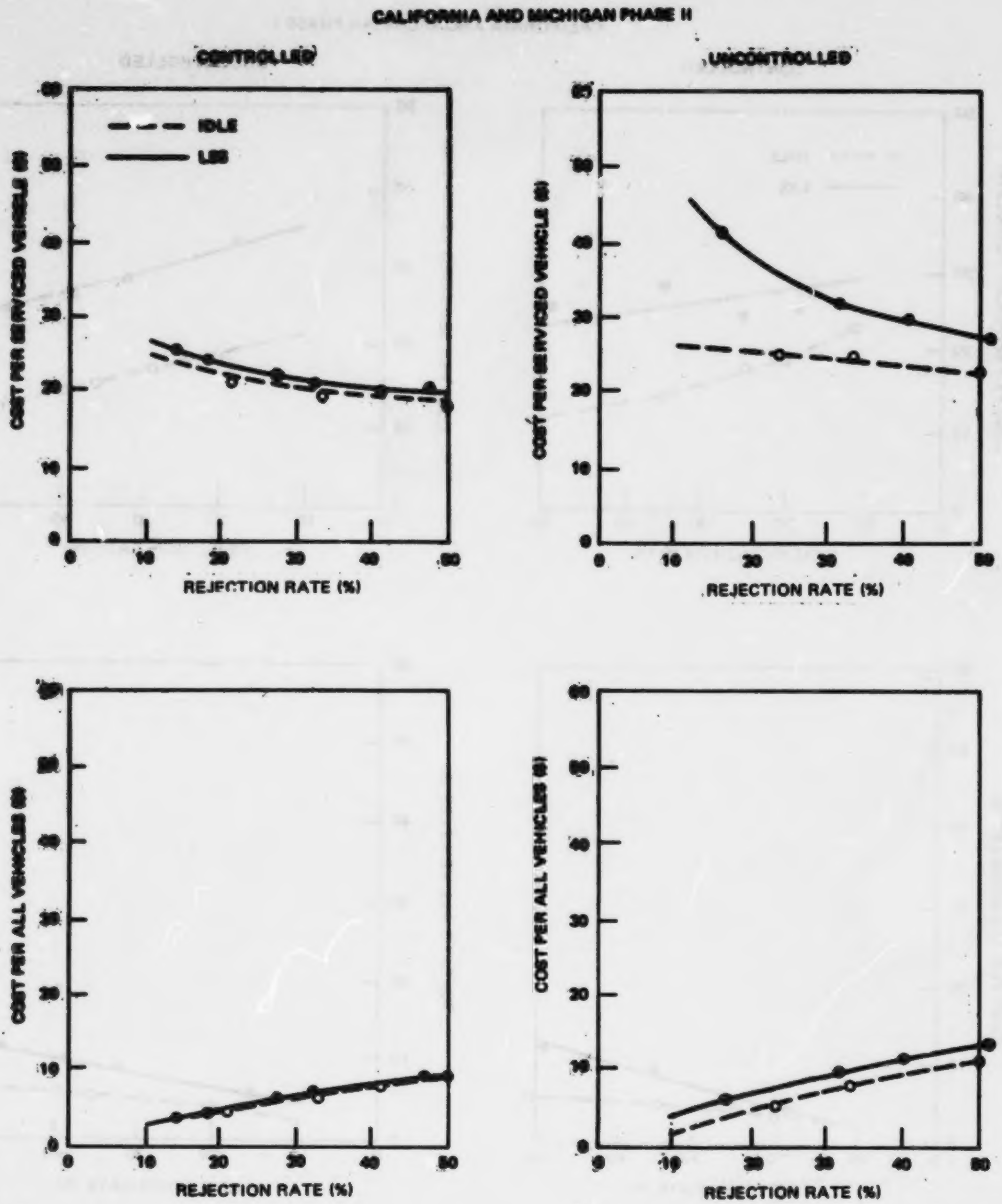


Figure 3-17. Average Vehicle Repair Costs Less Excess Repairs – Phase II

Reproduced from best available copy.

Figure 3-16 and 3-17 present the average vehicle repair costs after deleting excess repairs. Deletion of excess repair costs generally benefited Idle more than L.S.S. because more repairs were determined to be excessive for Idle than L.S.S.

In Phase I (Figure 3-16), deletion of excess costs reduced the average L.S.S. serviced vehicle repair cost 40% to 50% for controlled vehicles and about 40% for uncontrolled vehicles. Deletion of excess costs reduced the average serviced vehicle Idle repair cost about 30% at the 10% rejection rate and about 10% near a 50% rejection rate. Idle, therefore, was still less costly than L.S.S. at all rejection rates for HC and CO. Average serviced vehicle repair costs at approximately the 10% rejection rate were about 50% greater than at approximately the 50% rejection rate.

In Phase II (Figure 3-17), deletion of excess costs reduced the average L.S.S. serviced vehicle repair cost 40% to 50% for controlled vehicles but only slightly for uncontrolled vehicles. Deletion of excess costs reduced the average Idle serviced vehicle repair cost about 30% at about 10% rejection and 10% at about 50% rejection for controlled vehicles and 40% to 60% for uncontrolled vehicles. Average serviced vehicle repair costs were slightly lower for Idle than for L.S.S. on controlled vehicles but considerably lower on uncontrolled vehicles. Except for the uncontrolled L.S.S. vehicles, average serviced vehicle repair costs were 10% to 20% higher at approximately a 10% rejection rate than a 50% rejection rate.

3.4.2.4 Average Repair Cost for Service Actions

Table 3-30 presents the average cost of performing each category of service action. The average costs were determined for each phase, each state and controlled and uncontrolled vehicles. The repair categories are defined in paragraph 2.3.4. The service action cost was based on the actual first service repair cost. Estimated major mechanical repairs were based on list prices for parts, pay rate of $10 per hour, and average labor-hour rates from Chilton's flat rate manual.

In general, average repair cost for each service action was less for L.S.S. than for Idle. L.S.S. was 10% to 20% less expensive than Idle during carburetor repair in California. During Phase I, L.S.S. was 10% to 20% less expensive than Idle for ignition repairs in both California and Michigan and for carburetor repairs in Michigan. L.S.S. generally achieved lower costs on each service event. During Phase I particularly, the service events were undertaken more frequently, i.e., excessively, resulting in the higher cost per serviced vehicle. During Phase II, the California vehicles exhibited more severe carburetor malfunctions thereby increasing both Idle and L.S.S. costs for carburetor repairs.

Average repair cost experienced was $10 to $12 for minor adjustments, $5 to $8 for minor parts, $20 to $30 for ignition repairs and typically $35 for carburetor repairs. The highest average Phase I or II costs for service events were experienced by Idle regime vehicles for carburetor repairs. The lowest average Phase I or II costs for service events were experienced by L.S.S. Major mechanical repairs were not performed, however, costs were estimated. Three types of repairs were evaluated rather than the test regime because of the cost of repair was dependent on the type of vehicle identified

Table 3-30

AVERAGE COST FOR SERVICE EVENT

Service Event	California				Michigan				Combined			
	Phase I		Phase II		Phase I		Phase II		Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Minor Adjustments												
Controlled	8.25	8.50	10.40	7.90	13.18	12.48	12.78	9.50	11.07	9.38	11.59	8.83
Uncontrolled	10.81	14.31	12.32	10.42	12.74	14.85	14.52	9.17	11.65	13.58	13.20	9.90
All	10.00	12.10	11.75	9.64	12.92	14.09	13.76	9.33	11.43	12.18	12.64	9.48
Minor Parts												
Controlled	8.74	4.18	8.42	4.11	6.70	6.68	5.96	5.80	7.38	5.77	6.53	5.10
Uncontrolled	10.78	5.16	8.27	6.97	5.51	5.98	3.47	6.30	7.77	5.59	6.17	6.75
All	10.13	4.79	8.31	6.08	6.06	6.20	4.55	6.06	7.62	5.66	6.33	6.09
Ignition												
Controlled	30.28	38.90	22.80	23.43	27.20	27.97	21.46	18.63	28.57	29.18	21.73	21.83
Uncontrolled	29.06	21.14	26.59	20.34	30.86	25.10	23.85	28.35	29.96	23.62	25.02	23.77
All	29.45	27.91	25.47	21.30	29.34	26.02	22.81	23.70	29.38	25.14	24.15	22.87
Carburetor												
Controlled	N.P.	26.33	25.40	41.40	N.P.	27.50	N.P.	20.00	N.P.	26.92	25.40	36.05
Uncontrolled	N.P.	30.70	39.54	40.54	8.50	19.36	45.35	26.41	8.50	25.03	40.27	36.77
All	N.P.	29.04	35.35	40.81	8.50	21.96	25.63	23.34	8.50	25.57	38.62	36.62
Estimated Major Mechanical												
Leaking Head Gasket									149.33			
Valve Regrind									119.88			
Rings and Valves									290.71			

N.P. = work not performed

rather than the regime. Average repair costs were estimated at $150 for head gasket, $120 for valve regrind and $300 for overhaul including valve regrind and piston ring replacement.

The analysis indicated that L.S.S. enable mechanics to be more selective than Idle in making repairs when the service requirements of the vehicles were similar. Both lower cost for each service event as well as lower average serviced vehicle cost were achieved in Michigan during Phase II by L.S.S. when Idle and L.S.S. failures were predominately due to idle maladjustments or malfunctions. In the other cases where individual service event costs were lower for L.S.S. than for Idle, but the average serviced vehicle cost was higher; L.S.S. garages performed each type of work more frequently than the Idle garages. If the L.S.S. garages were more sensitive to performing minimum work, as during Phase II in Michigan, lower serviced vehicle cost should result. L.S.S. service cost should be expected to be higher than Idle only when the types of malfunctions occurring require extensive carburetor repair because of L.S.S. cruise mode failures such as occurred in Phase II.

3.4.2.5 Average Repair Cost for Correcting Idle Malfunctions Only

The average repair cost was determined for only those vehicles which did not have cruise mode failures indicated by L.S.S. data. Table 3-31 presents the average repair cost for idle failures only using costs actually experienced and the cost deleting excess repairs. Table 3-31 indicates that L.S.S. was less expensive than Idle in performing repairs to correct malfunctions which did not result in cruise mode failures. L.S.S. provided this lower cost in every case except Michigan, Phase I, where the very high excess repair rate occurred. After correcting for excess repairs, the cost of Idle and L.S.S. were generally about $17 per vehicle. This was more than the cost of minor adjustments but slightly less than the cost of minor adjustment plus minor parts as shown in Table 3-30. Table 3-31 also contains the fleet average repair costs corresponding to the serviced vehicle average.

3.4.3 Total Program Costs

The inspection cost and maintenance cost were combined in order to determine the estimated total cost of conducting Idle and L.S.S. PVIM programs in California and Michigan. The analyses also permitted assessment of the average vehicle owner cost. The inspection cost was taken from Table 3-26. The average maintenance cost per vehicle was taken from Table 3-28 and multiplied by the vehicle population in each state.

Table 3-32 presents the total program costs for each Phase and for each state separately and added together. The inspection program cost was not dependent on maintenance practice, therefore the same inspection program cost was assigned to both phases. The maintenance cost was shown to vary, however, reflecting the different average maintenance costs in each Phase. The inspection cost represents a relatively small part of the total program cost even after deducting excess repair cost. The inspection cost would represent a larger proportion of the total cost if the program was operated at a lower rejection rate. Total costs were higher in California than in Michigan reflecting the larger vehicle population in California. Total costs were lower during Phase II than Phase I except for the California L.S.S. fleet which had the large number of high emitters during Phase II.

Idle was generally less costly than L.S.S. During Phase II in Michigan, however, L.S.S. was less costly than Idle due to the low repair cost. Excess repair costs totalling about $40 million in Phase I were incurred by both the Idle and L.S.S. regimes. In Phase II, total excess repair costs for the Idle and L.S.S. regimes averaged about $60 million and $20 million respectively.

Table 3-31

AVERAGE REPAIR COST OF CORRECTING IDLE ONLY FAILURES
(Dollars Per Vehicle)

Vehicle Fleet	Phase I		Phase II	
	Actual Cost	Less Excess Cost	Actual Cost	Less Excess Cost
Serviced Vehicle				
California				
Idle	28.39	18.31	24.12	14.14
L.S.S.	26.67	20.85	21.27	18.75
Michigan				
Idle	29.81	16.86	29.58	18.70
L.S.S.	40.61	19.12	15.20	14.94
Combined				
Idle	29.13	17.56	27.13	16.66
L.S.S.	35.20	19.79	17.71	16.52
All Vehicles				
California				
Idle	4.54	2.93	4.18	2.45
L.S.S.	4.27	3.34	3.40	3.00
Michigan				
Idle	5.23	2.96	6.31	3.99
L.S.S.	6.59	3.10	2.43	2.39
Combined				
Idle	4.89	2.95	5.25	3.22
L.S.S.	7.32	4.12	3.42	3.19

The vehicle owner costs were also presented in Table 3-32. The costs permitted evaluation of cost recovery in a self supporting program. The first year costs for a passed vehicle were between $2 and $3 if all investment costs were paid the first year. Thereafter, or if the investment cost was distributed over many years, the inspection costs for a passed vehicle were $1.16 for Idle and $1.35 for L.S.S.

Table 3-32

FIRST YEAR TOTAL PROGRAM COST (MILLIONS OF DOLLARS)
30% Rejection Rate

Cost Element	California				Michigan				Combined			
	Phase I		Phase II		Phase I		Phase II		Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Inspection (PVI)												
First Year Capital	22	31	22	31	12	17	12	17	40	48	40	48
Capital Amortized	12	14	12	14	6	7	6	7	18	21	18	21
Maintenance (M)												
Actual Cost	77	89	119	147	49	76	50	38	126	165	169	185
Less Excess Cost	51	78	77	125	32	46	35	35	83	124	112	160
Total Program (PVIM)												
First Year Capital												
Actual Cost	99	120	141	178	61	93	62	55	166	213	209	233
Less Excess Cost	73	109	99	156	44	63	47	52	128	172	152	208
Capital Amortized												
Actual Cost	89	103	121	161	54	83	56	45	144	186	187	206
Less Excess Cost	63	92	89	139	38	53	41	42	101	145	130	181
Vehicle Owner Cost*												
Passed Vehicle	1.16	1.35	1.16	1.35	1.16	1.35	1.16	1.35	1.16	1.35	1.16	1.35
Failed Vehicle												
Actual Cost	27.36	33.12	28.46	42.39	33.57	39.27	30.82	23.69	27.94	38.16	32.30	32.38
Less Excess Cost	18.62	29.28	19.21	25.86	22.61	33.54	21.87	22.05	18.93	27.42	22.27	28.46

*Vehicle owner cost in dollars per year

The owner of a failed vehicle would pay both the inspection fee and the cost of repairs. For the average failed Idle regime vehicle, the owner's total cost was $28 in Phase I and $32 in Phase II. For the average failed L.S.S. regime vehicle, the owners total cost was $38 in Phase I and $32 in Phase II. Owner costs were lower in Michigan than in California, except for the Phase I L.S.S. fleet due to the high excess cost in Michigan. After deducting the excess repair costs the average failed vehicle cost was $18 to $22 for Idle and $27 to $29 for L.S.S.

The owner of a failed and subsequently serviced vehicle could expect some fuel savings due to the adjustments and repairs required to lower emissions. L.S.S. exhibited greater annual fuel savings ($31) than Idle ($9) in Phase II. Idle did not exhibit greater savings than L.S.S. in either California or Michigan. In California, however, both Idle and L.S.S. incurred negative fuel savings on controlled vehicles. The fuel savings for L.S.S. were consistent with the large emission reductions experienced during Phase II.

3.5 COST EFFECTIVENESS ANALYSIS

This section presents the results of the cost effectiveness analysis which combines the emission reductions determined in the Effectiveness Analysis (Section 3.2) and the Cost Analysis (Section 3.4). The specific methodology is described in paragraph 2.3.6. Cost effectiveness is presented in terms of the cost effectiveness index, as a function of Inspection Test Rejection Rate, and for the Correction of Idle Malfunctions Only.

3.5.1 Cost Effectiveness Index

The cost effectiveness index (shown in Table 3-33) combines the annual emission reductions of the effectiveness index and the annual total program cost to give statewide first year cost effectiveness in terms of pounds of emission reduction per dollar of cost. The effectiveness data from Table 3-18 calculated for equal weighting of pollutants were utilized. The cost data from Table 3-32 were utilized for only inspection costs, only maintenance costs, only maintenance cost deleting excess repair, and the sum of inspection and maintenance costs with and without excess repairs deleted.

For the total program cost using amortized capital and actual repair cost; Idle was 41% more cost effective in reducing emission than L.S.S. during Phase I. L.S.S. was 52% more cost effective in reducing emissions during Phase II. In Phase I, Idle was always more cost effective than L.S.S. In Phase II, L.S.S. was more cost effective than Idle, except in Michigan where Idle was more cost effective if only inspection cost was used. Idle cost effectiveness did not change significantly between Phases. L.S.S., however, was nearly twice as cost effective in Phase II as during Phase I. The change in L.S.S. cost effectiveness was due to improved emission reduction in California and lower average repair cost in Michigan compared to Phase I results. The improved L.S.S. performance was related to correct instruction in the application of the diagnostic information of the modal failure data during Phase II.

Table 3-33

FIRST YEAR PROGRAM COST EFFECTIVENESS - 1975 CVS Data
30% Failure Rate
Annual Pounds Reduction Per Dollar

Cost Element	California				Michigan				Combined			
	Phase I		Phase II		Phase I		Phase II		Phase I		Phase II	
	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.	Idle	L.S.S.
Inspection (PVI)												
First Year Capital	91	60	126	172	125	79	93	73	88	67	97	137
Amortized Capital	167	133	231	381	251	192	185	177	195	153	216	313
Maintenance Cost (M)												
Actual Cost	26	21	23	36	31	18	22	33	28	19	23	36
Less Excess Cost	39	24	36	43	47	29	32	35	42	26	35	41
Total Program Cost (PVIM)												
First Year Capital												
Actual Cost	20	16	20	30	25	14	18	23	21	15	19	28
Less Excess Cost	28	17	28	34	34	21	24	24	27	19	26	32
Amortized Capital												
Actual Cost	23	18	23	33	28	16	20	28	24	17	21	32
Less Excess Cost	32	20	31	38	40	25	27	30	35	22	30	36

Effectiveness Values from Table 3-18 (Tons Per Year - Equal Pollutant Weighting).
Cost Values from Table 3-32.

3.5.2 Cost Effectiveness as a Function of Inspection Test Rejection Rate

The fleet average cost effectiveness of Idle and L.S.S. was calculated by dividing the average emission reductions of HC and CO by the average vehicle repair cost. The analysis utilized actual repair cost and repair cost deleting excess repairs and was based on combined California and Michigan data for each Phase. Figures 3-18 and 3-19 present the cost effectiveness of HC and CO emission reductions.

In Phase I (Figure 3-18), maximum cost effectiveness generally occurred at the lowest rejection rate. Minimum cost effectiveness generally occurred at the highest rejection rate. Idle was more cost effective than L.S.S. at all rejection rates for HC and CO. Both Idle and L.S.S. were more cost effective in reducing CO than HC. Idle was more cost effective in reducing HC and CO emissions from uncontrolled vehicles than controlled vehicles. L.S.S. was slightly more cost effective for HC on uncontrolled than controlled vehicles but essentially equally cost effective for CO on uncontrolled and controlled vehicles. After deleting excess repair costs, Idle was still more cost effective than L.S.S. at all rejection rates for HC and CO.

In Phase II (Figure 3-19), cost effectivenss also tended to be highest at lower rejection rates. L.S.S., however, was more cost effective than Idle at all rejection rates for HC and CO on uncontrolled vehicles and for HC on controlled vehicles. Idle was marginally more cost effective for CO on controlled vehicles. L.S.S. cost effectiveness was more dependent on rejection rate than Idle. Idle and L.S.S. were over twice as cost effective in reducing HC on uncontrolled vehicles than controlled vehicles. Idle was equally cost effective in reducing CO on controlled and uncontrolled vehicles. L.S.S. was 50% more cost effective in reducing CO from uncontrolled than controlled vehicles. After deleting excess repair costs, L.S.S. was more cost effective than Idle in reducing HC and CO emissions from controlled vehicles and CO emissions from uncontrolled vehicles. Idle was slightly more cost effective than L.S.S. for HC emissions from uncontrolled vehicles.

3.5.3 Cost Effectiveness of Correcting Idle Malfunctions Only

This paragraph combines the emission reductions and repair cost determine for those vehicles which failed only idle mode test values. The L.S.S. data recorded for both Idle regime vehicles and L.S.S. regime vehicles was used to select those vehicles in each fleet which were known to have failing emissions only at idle. The emission reductions from Idle and L.S.S. would be expected to be less for the L.S.S. vehicles, however, because the L.S.S. garages would be certain the failure was only due to idle adjustment.

Table 3-34 presents the results of the cost effectiveness of correcting idle emission failures only. The results were calculated by summing the HC, CO and NO_x gram per mile emission reductions and dividing by the sum of the cost of repair for the same vehicles. The resulting index provided cost effectiveness in terms of grams per mile per service cost dollar. Data are presented for each Phase using actual repair cost and repair cost deleting excess repairs. The actual repair cost should be used to interpret the relative diagnostic capability of Idle and L.S.S. The repair cost less excess repairs represents the ideal situation where both Idle and L.S.S. garages make the best use of the information available to them.

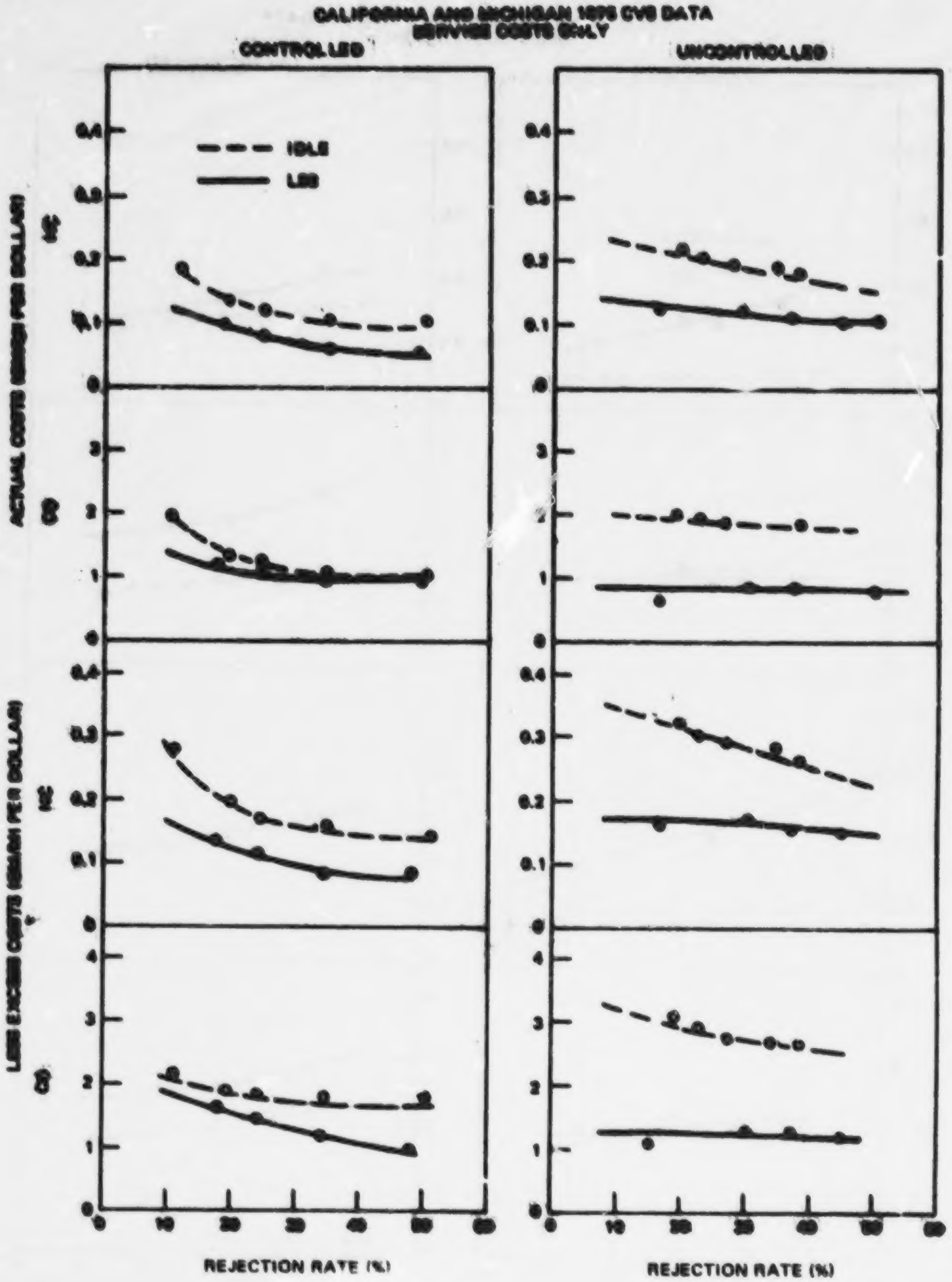


Figure 3-18. Cost Effectiveness as a Function of Failure Rate – Phase I

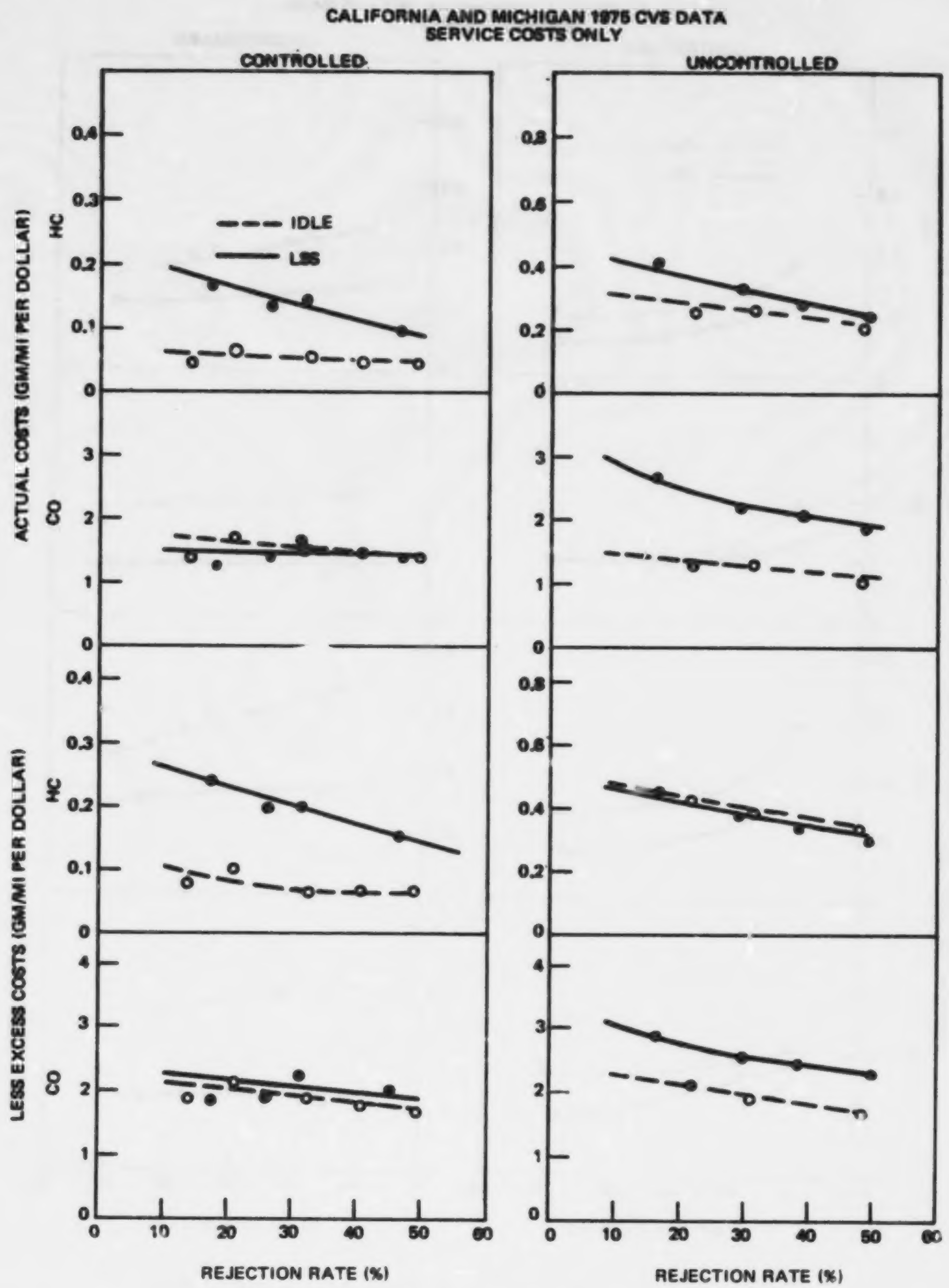


Figure 3-19. Cost Effectiveness as a Function of Failure Rate – Phase II

L.S.S. was found to be more cost effective than Idle in all cases for repairing vehicles with only idle malfunctions. In Phase I, L.S.S. was 10% more cost effective than Idle. In Phase II, L.S.S. was 110% more cost effective than Idle in repairing vehicles with only idle emission failures. Idle cost effectiveness improved slightly from Phase I to Phase II. L.S.S. cost effectiveness in Phase II was 120% greater than in Phase I. This improvement was due to much lower L.S.S. repair cost incurred on these vehicles during Phase II compared to Phase I. After deducting excess repairs, L.S.S. in Phase II was 40% more cost effective than Idle.

Table 3-34

FLEET COST EFFECTIVENESS OF CORRECTING IDLE ONLY FAILURES
Grams Per Mile Per Dollar

Vehicle Fleet	Phase I		Phase II	
	Actual	Less Excess	Actual	Less Excess
California				
Idle	0.90	1.40	1.00	1.71
L.S.S.	1.09	1.42	2.25	2.55
Michigan				
Idle	1.38	2.44	1.55	2.46
L.S.S.	2.05	4.36	4.58	4.66
Combined				
Idle	1.16	1.92	1.33	2.17
L.S.S.	1.24	2.20	2.75	2.95

Effectiveness Values from Table 3-13.
Cost Values from Table 3-31 for All Vehicles.

3.6 RELATIBILITY ANALYSIS

This section presents the results of the correlation analysis of the 21 candidate inspection tests relative to the 1972 and 1975 CVS test procedures and the errors of commission resulting from Idle and L.S.S. inspections. These analyses are presented for the combined Phase I and Phase II test fleets since the larger sample sizes provide greater confidence in the conclusions and changes in the maintenance procedures would not affect the reliability criteria used for the analysis.

3.6.1 Correlation and Regression Results

This paragraph presents regression and correlation coefficients of the various short emission inspection tests relative to the 1975 CVS test. The discussion is limited to before service data only. Complete regression tables of 1975 CVS data, before and after service, are shown in Appendix C.

Each of the short inspection tests was correlated to the 1972 CVS and 1975 CVS test using a linear regression of the form:

$$y = a + \sum_{i=1}^{n} b_i x_i$$

where y = 1972 or 1975 CVS in grams per mile

a = intercept of regression

b_i = coefficients of independent variables

x_i = emission values of short inspection test in concentration units

n = number of separate modes

In case of multiple regression, i.e., the steady state tests like L.S.S. this equation considers each speed as follows:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3$$

where b_1, b_2, b_3 = the Idle, Low Cruise, and High Cruise coefficients

x_1, x_2, x_3 = the Idle, Low Cruise, and High Cruise emission values in concentration units

In general, the mass (CVS) tests related considerably better to the 1975 CVS data than did any volumetric tests. Tables 3-35 to 3-37 rank the 1972 CVS and 10 common short tests with respect to how well they correlate with the 1975 CVS test (before service data) for California, Michigan and the combined states respectively. Each Idle and L.S.S. fleet contained 150 vehicles. With no exceptions, the best correlation occurred between the 1972 and 1975 CVS mass tests. The EPA Short CVS Test and the mass emission multiple stepwise regression shared second best relatability. Of the 22 emission tests whose correlation coefficients were ranked, the 6 mass tests generally ranked in the upper quarter while the volumetric tests generally did not rank in the upper half of the groups. Volumetric L.S.S. was ranked 11th and 9th best correlation for HC in California and Michigan respectively. Volumetric L.S.S. was ranked 11th and 10th best correlated for CO in California and Michigan respectively. Volumetric L.S.S. was 9th and 5th best correlated for NO_x in California and Michigan respectively. Idle correlation ranked 22nd best for HC and CO in both California and Michigan. Idle NO_x correlation ranked 21st best in California and 19th best in Michigan. Two volumetric tests which generally ranked higher than L.S.S. for HC and CO were the hot start 7-Mode and the multiple stepwise regression of steady state speeds. If all the inspection tests performed had been listed, some

Table 3-35

RANKING OF SHORT INSPECTION TEST
CORRELATION TO 1975 CVS TEST
300 California Vehicles

Short Test	HC		CO		NO_x	
	California Cars	Rank	California Cars	Rank	California Cars	Rank
Mass Tests						
1972 CVS	0.995	1	0.976	1	0.979	1
EPA Short	0.965	4	0.892	3	0.844	2
7-Mode	0.937	5	0.859	5	0.785	3
L.S.S.	0.966	2	0.891	4	0.742	5
Best 1 Speed	(30) 0.931	6	(40) 0.823	7	(50) 0.740	6
Step Combined	0.965	3	0.892	2	0.766	4
Volumetric Tests						
7-Mode	0.773	17	0.852	6	0.577	14
L.S.S.	0.824	11	0.775	11	0.680	9
Best 1 Speed	(40) 0.804	14	(40) 0.734	14	(50) 0.646	11
Step Combined	0.818	13	0.778	10	0.669	10
Idle	0.513	22	0.534	22	0.038	21

Numbers in parentheses are the best correlated single speeds

Table 3-36

RANKING OF SHORT INSPECTION TEST CORRELATION TO 1975 CVS TEST
300 Michigan Vehicles

Short Test	HC		CO		NO_x	
	Michigan Cars	Rank	Michigan Cars	Rank	Michigan Cars	Rank
Mass Tests						
1972 CVS	0.987	1	0.963	1	0.978	1
EPA Short	0.932	2	0.852	5	0.799	2
7-Mode	0.920	4	0.855	3	0.545	14
L.S.S.	0.933	3	0.854	4	0.757	4
Best 1 Speed	(40) 0.886	7	(20) 0.782	8	(60) 0.709	7
Step Combined	0.916	5	0.872	2	0.730	6
Volumetric Tests						
7-Mode	0.883	8	0.808	7	0.779	3
L.S.S.	0.877	9	0.768	10	0.757	5
Best 1 Speed	(60) 0.869	10	(40) 0.714	13	(60) 0.638	10
Step Combined	0.894	6	0.808	6	0.653	9
Idle	0.747	22	0.548	22	0.168	19

Numbers in parentheses are the best correlated single speeds

Table 3-37

RANKING OF SHORT INSPECTION TEST CORRELATION TO 1975 CVS TEST
Combined States

Short Test	HC		CO		NO_x	
	All Cars	Rank	All Cars	Rank	All Cars	Rank
Mass Tests						
1972 CVS	0.991	1	0.970	1	0.980	1
EPA Short	0.949	3	0.874	3	0.833	2
7-Mode	0.929	5	0.856	5	0.643	10
L.S.S.	0.951	2	0.873	4	0.752	3
Best 1 Speed	(30) 0.892	6	(40) 0.796	7	(50) 0.699	6
Step Combined	0.936	4	0.883	2	0.731	4
Volumetric Tests						
7-Mode	0.819	12	0.832	6	0.628	11
L.S.S.	0.812	13	0.766	11	0.726	5
Best 1 Speed	(40) 0.798	14	(40) 0.717	13	(60) 0.626	12
Step Combined	0.821	11	0.785	9	0.655	9
Idle	0.602	22	0.536	22	0.058	20

Numbers in parentheses are the best correlated single speeds

single constant speed mass tests would have ranked higher than some of the volumetric tests. Rank of correlation of the short inspection tests relative to the 1975 CVS test was generally similar for HC, CO and NO_x emissions.

Typically, the single best correlated constant speed tests did not relate as well as any of the other tests considered. The single constant speed of 40 mph was best related for CO and HC while 60 mph was best related for NO_x. In no case was the best single speed more closely related to the 1975 CVS than the L.S.S. test. In every case, the best single speed was more correlated than Idle.

Figures 3-20 to 3-22 depict the degree of improvement achieved in correlation between multiple constant speed tests and the 1975 CVS test as various speeds are sequentially incorporated into the multiple linear regression equation. In considering the L.S.S. test, the Low Cruise measurement provided the greatest relatability to the 1975 CVS, followed by the idle and lastly by the High Cruise measurements. This observation agrees with that regarding the constant speed tests (best correlation at 40 mph). The data show that, in general, addition or deletion of the least correlated mode (typically High Cruise) has a relatively small impact on how strongly the L.S.S. test is related to the 1975 CVS test. In most cases for HC and CO, the complete L.S.S. test related to the CVS as well as did a different combination of three constant speed tests. For NO_x the L.S.S. test related to the CVS better than a different combination of three speeds. This occurred because of the higher dynamometer load used for the L.S.S. test.

When the volumetric constant speed tests were subjected to the same analysis as above, it was generally found that only small improvements in relatability were gained by incorporating more than four separate speeds (regardless of the specific speeds) into the multiple regression equation. Figures 3-20 to 3-22 show the improved correlation from incorporating additional speeds and indicate which speed was selected. The results show that the gain on correlation coefficient after the second speed is added is small. Although it may be enough to change the rank of the multiple regression, the true improvement in standard error or correlation coefficient would be small.

Tables 3-38 to 3-40 present the actual regression, correlation coefficients and standard error for several common short inspection tests relative to the 1975 test. As expected, the 1972 CVS and 1975 CVS tests are highly correlated to each other. The slope, b, of the regression line is very close to unity in all cases (representing nearly a one-to-one relationship). When the characteristics derived for the sample vehicles were projected to a larger population, the 90% confidence interval for a and b were on the order of ±10-50% of the average value. In addition, the 90% confidence interval of the expected population correlation coefficient was only ±0-2% of the average value.

Since standard errors (SE) are in absolute values rather than percentages, they will be proportionately larger for HC and NO_x and larger still for CO.

The 1972 CVS and 1975 CVS tests replicated each other very closely because they were calculated from the same test data. Therefore, it was not necessary

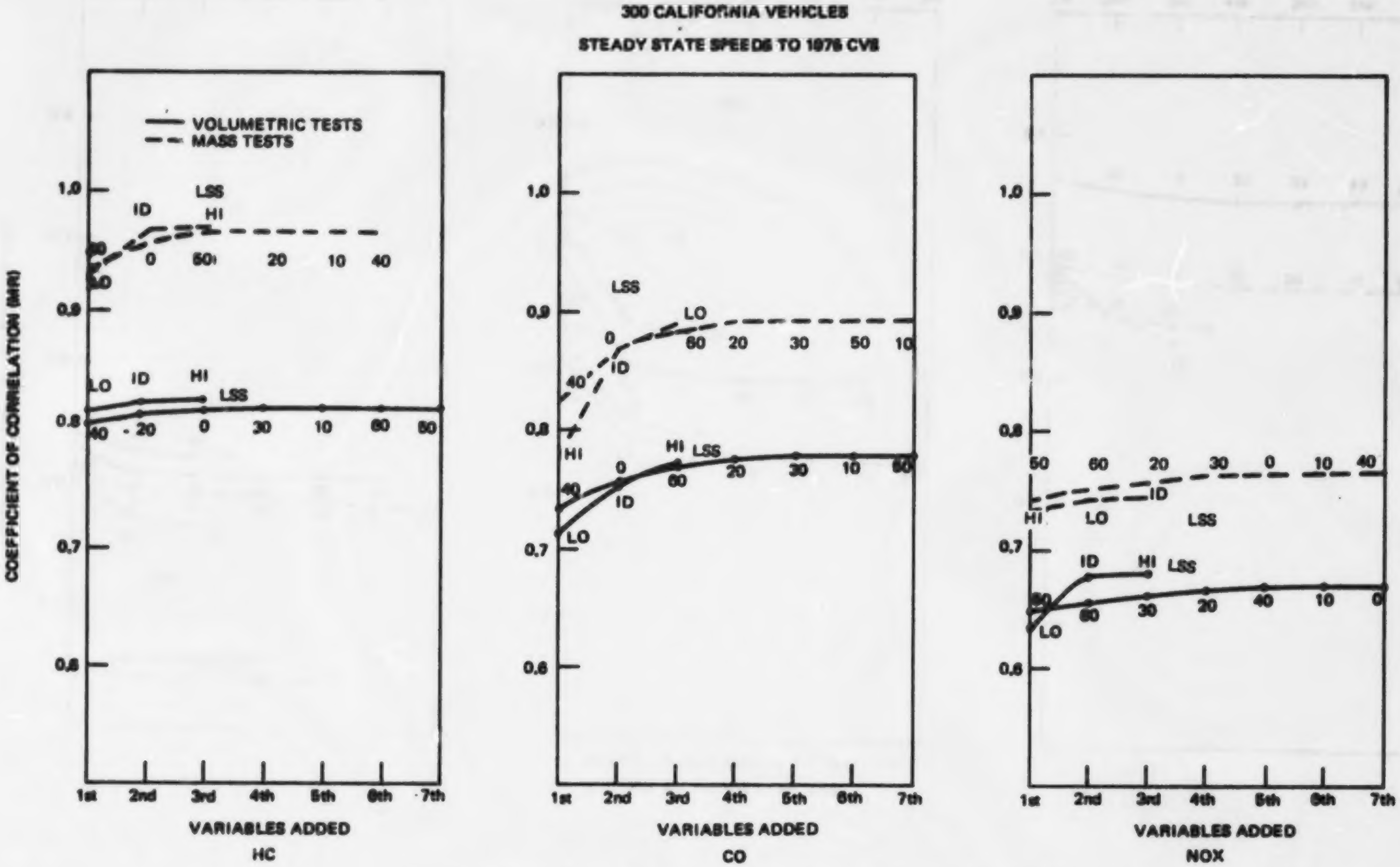


Figure 3-20. Dependence of Correlation on Number of Steady State Speeds - California

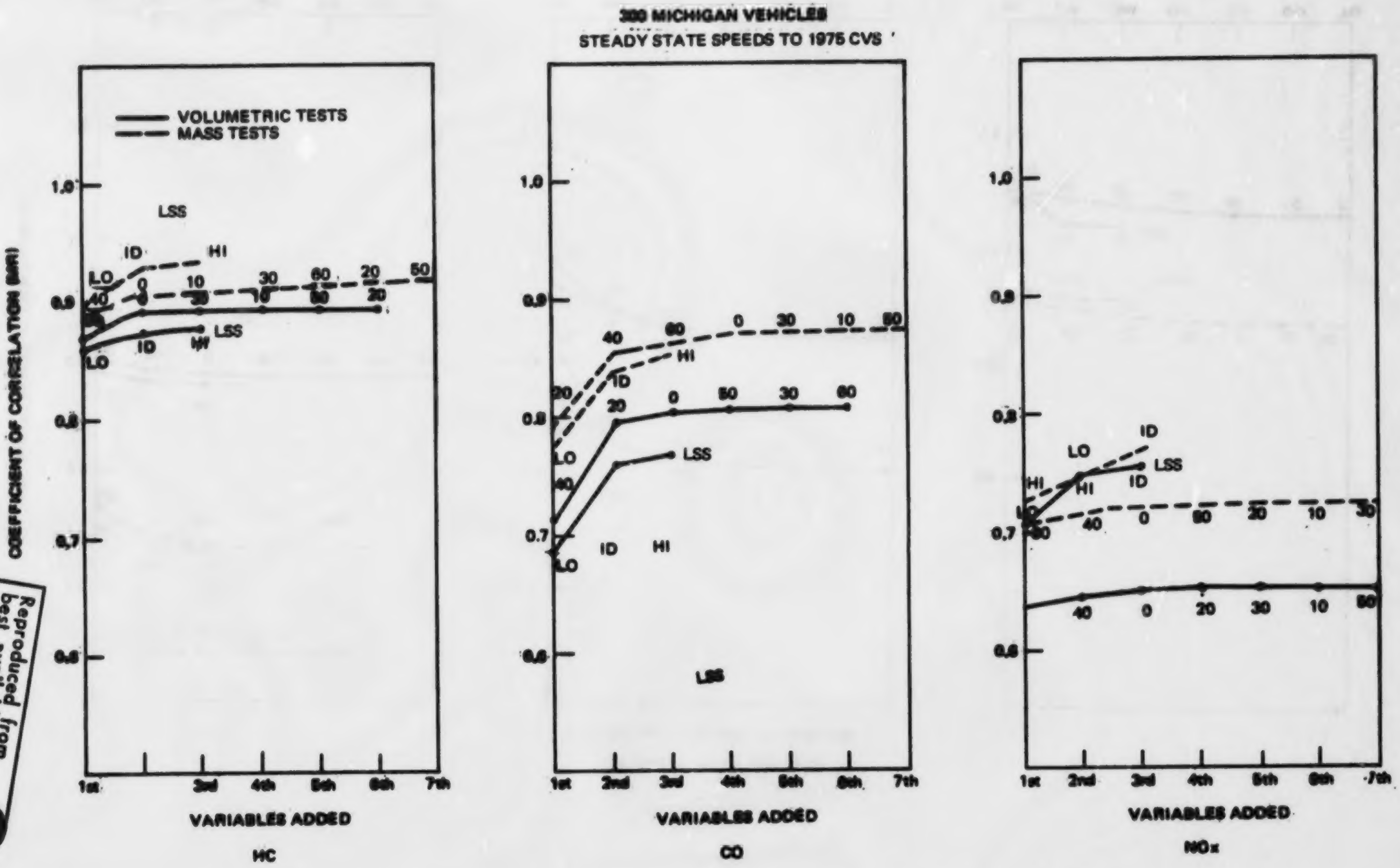


Figure 3-21. Dependence of Correlation on Number of Steady State Speeds - Michigan

Reproduced from best available copy.

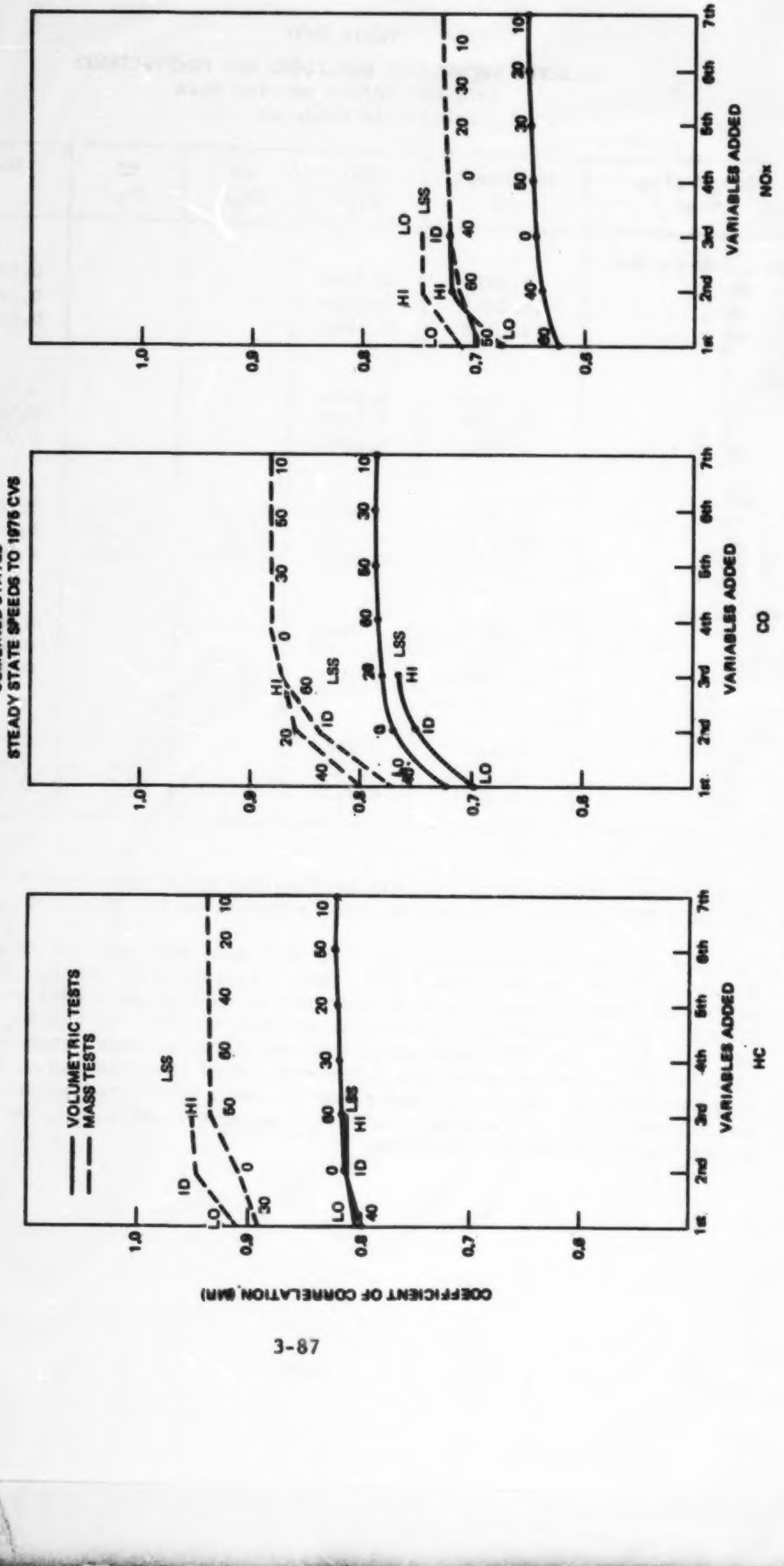


Figure 3-22. Dependence of Correlation on Number of Steady State Speeds - All Vehicles

Table 3-38

SELECTED REGRESSION EQUATIONS AND COEFFICIENTS
1975 CVS Before Service Data
California Vehicles Only

Inspection Test	Intercept (a)	Idle (b_1)	LO (b_2)	HI (b_3)	MR	SE (gr/mi)
Vol. 7-Mode Hot						
HC	2.3923	0.9340			0.7728	5.220
CO	20.2859	1.1027			0.8523	28.106
NO_x	1.5528	0.3492			0.5765	1.299
Idle						
HC	4.7249	0.0050			0.5026	7.110
CO	39.5000	9.5787			0.5335	45.443
NO_x	2.8447	0.0003			0.0375	1.589
L.S.S.						
HC	1.6976	0.0015	0.0179	0.0011	0.8236	4.680
CO	28.8946	4.6394	7.5289	8.1215	0.7751	34.064
NO_x	0.5871	-0.0004	0.0007	0.0006	0.6803	1.170
EPA Short						
HC	0.8550	1.1919			0.9646	2.169
CO	26.5726	1.0568			0.8918	24.309
NO_x	0.7265	0.9129			0.8439	0.853
1972 CVS						
HC	-0.4154	0.9647			0.9951	0.816
CO	-2.9559	0.9150			0.9760	11.704
NO_x	0.0907	0.9738			0.9794	0.321

to perform a relatability analysis between the short tests and both CVS tests. The 1975 CVS test has, therefore, been selected as the standard for comparison.

In summary, the tables showed that the Idle Mode test was not as well related to the 1975 test as was the L.S.S. test. In addition, the L.S.S. test exhibited greater consistency of correlation coefficients (MR) within subfleets. As was expected, correlation of Idle to 1975 CVS for NO_x measurements was very low. The Idle test exhibited considerable larger standard error (dispersion of points about the regression line) than the L.S.S. test for every pollutant. The L.S.S. was among the best correlated volumetric tests and the numerical difference in standard error between L.S.S. and the other highly ranked volumetric tests was small.

Table 3-39

SELECTED REGRESSION EQUATIONS AND COEFFICIENTS
1975 CVS Before Service Data
Michigan Vehicles Only

Inspection Test	Intercept (a)	Idle (b_1)	LO (b_2)	HI (b_3)	MR	SE (gr/mi)
Vol. 7-Mode Hot						
HC	2.4726	0.8586			0.8828	3.282
CO	22.4287	1.1282			0.8083	28.073
NO_x	1.2022	0.7057			0.7785	1.119
Idle						
HC	2.9411	0.0076			0.7468	4.647
CO	37.3501	8.6881			0.5482	39.876
NO_x	3.2293	0.0095			0.1666	1.758
L.S.S.						
HC	2.7488	0.0042	0.0029	0.0049	0.8769	3.370
CO	26.3030	5.4242	11.5993	5.6597	0.7676	30.662
NO_x	0.7652	0.0013	0.0008	0.0007	0.7488	1.180
EPA Short						
HC	1.2955	1.0383			0.9331	2.513
CO	29.4849	0.9896			0.8524	24.927
NO_x	1.3678	0.8023			0.7990	1.073
1972 CVS						
HC	-0.3368	0.9276			0.9869	1.125
CO	0.4609	0.8572			0.9692	12.859
NO_x	0.2276	0.9799			0.9784	0.368

Figures 3-23 through 3-30 present the regression equation confidence bands for combined Phase I and II before service data. The confidence bands are presented for HC and CO emissions and for controlled and uncontrolled vehicles. The regression equation confidence bands enclose the range of actual CVS emission values which could correspond to a predicted CVS emission value calculated from Idle or L.S.S. data. For example, Figure 3-23, if a vehicle were tested for Idle HC emission and a corresponding predicted 1975 CVS value of 12 grams per mile were obtained there is 90% confidence that the same vehicle would have actual 1975 CVS emissions between 0 and 24 grams per mile. In the case of L.S.S., Figure 3-24, if a vehicle experienced L.S.S. emissions corresponding to a predicted 1975 CVS value of 12 grams per mile there is 90% confidence that the range of actual 1975 CVS emissions could range from 4 to 20 grams per mile. In general, the figures may be summarized as follows:

Table 3-40

SELECTED REGRESSION EQUATIONS AND COEFFICIENTS
1975 CVS Before Service Data
Combined States

Inspection Test	Intercept (a)	Idle (b_1)	LO (b_2)	HI (b_3)	MR	SE (gr/mi)
Vol. 7-Mode Hot						
HC	2.4402	0.8939			0.8195	4.367
CO	21.5273	1.1121			0.8325	28.100
NO_x	1.5716	0.4845			0.6278	1.387
Idle						
HC	4.0103	0.0060			0.6019	6.085
CO	39.0298	8.9689			0.5359	42.827
NO_x	3.5665	-0.0007			0.0580	1.779
L.S.S.						
HC	2.7010	0.0018	0.0108	0.0018	0.8120	4.455
CO	27.6412	5.2628	8.8230	6.8602	0.7665	32.632
NO_x	0.6863	-0.0005	0.0009	0.0006	0.7258	1.228
EPA Short						
HC	1.0422	1.1191			0.9490	2.403
CO	27.8139	1.0250			0.8743	24.626
NO_x	0.9690	0.8755			0.8336	0.984
1972 CVS						
HC	-0.3959	0.9485			0.9912	0.997
CO	-1.4310	0.8871			0.9696	12.402
NO_x	0.1158	0.9900			0.9802	0.353

- there is 90% confidence that the actual 1975 CVS emissions of a vehicle will be within plus or minus 80% of the value predicted by Idle test data.
- there is 90% confidence that the actual 1975 CVS emissions of a vehicle will be within plus or minus 60% to 70% of the value predicted by L.S.S. test data.

The above results suggest that neither Idle nor L.S.S. were statistically good predictors of 1975 CVS emissions from individual vehicles. In the case of fleet (more than 30 vehicles) emissions, however, Idle and L.S.S.

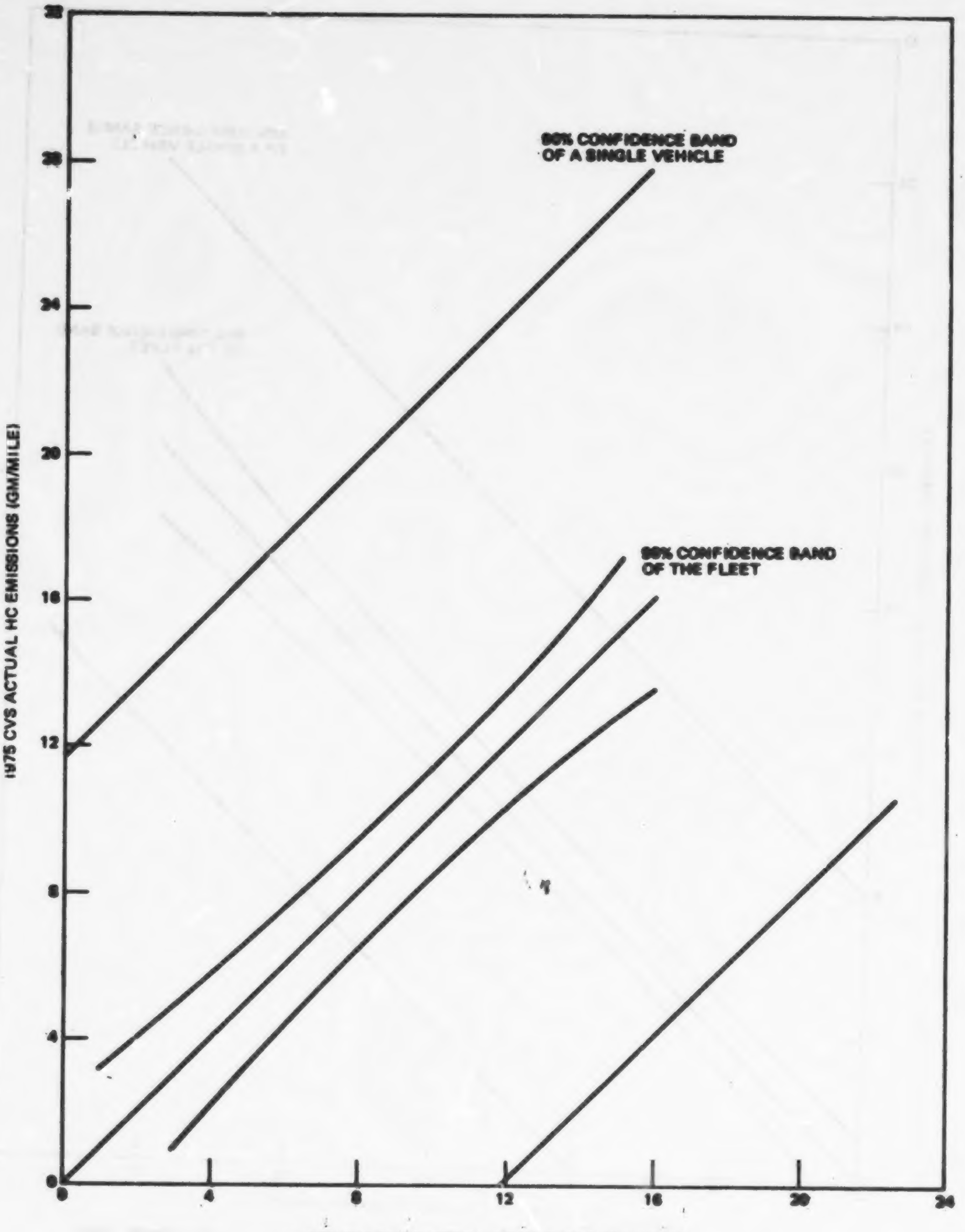


Figure 3-28. HC Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test – Phase I and II Uncontrolled Vehicles

Reproduced from
best available copy.

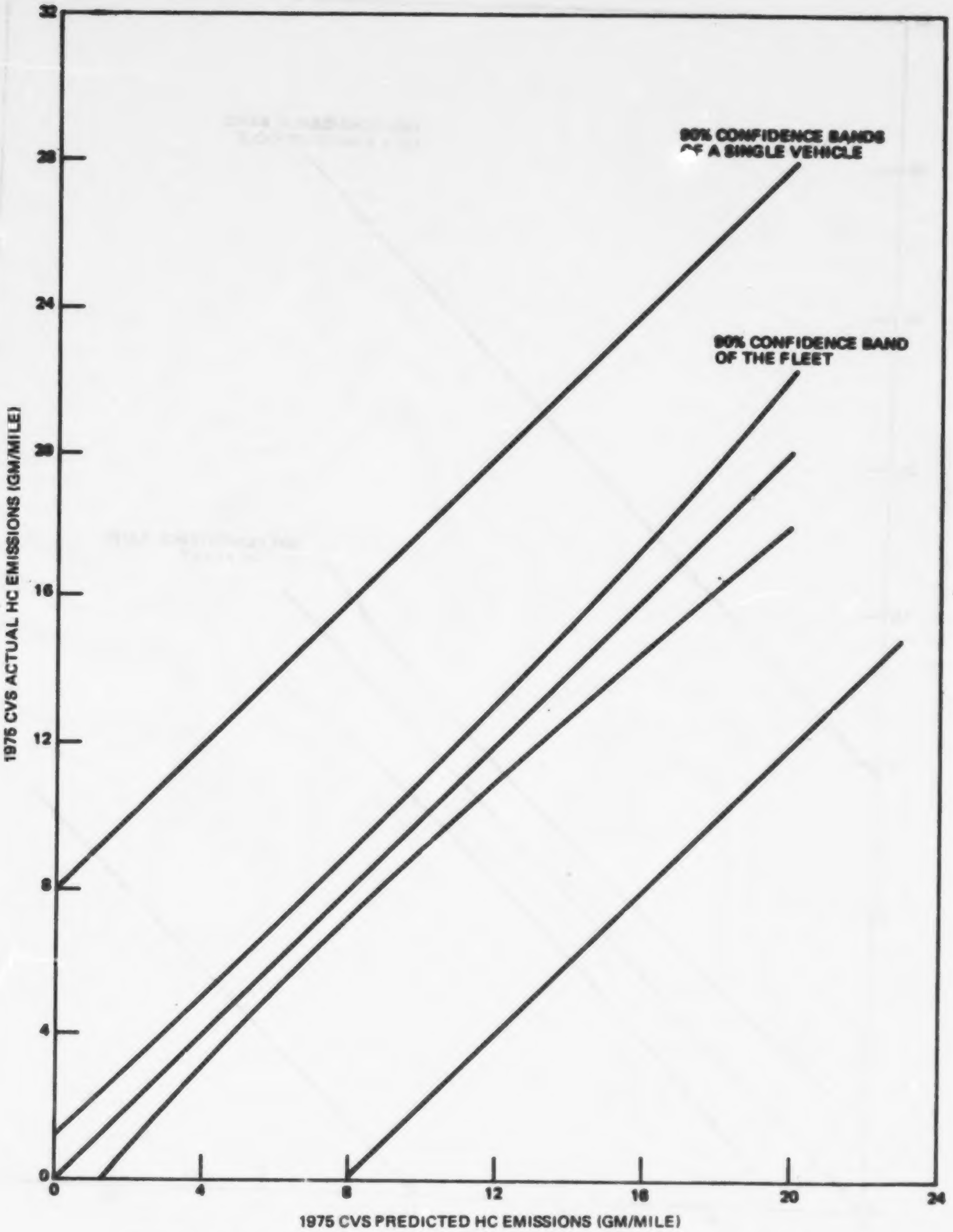


Figure 3-24. HC Confidence Band of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test – Phase I and II Uncontrolled Vehicles

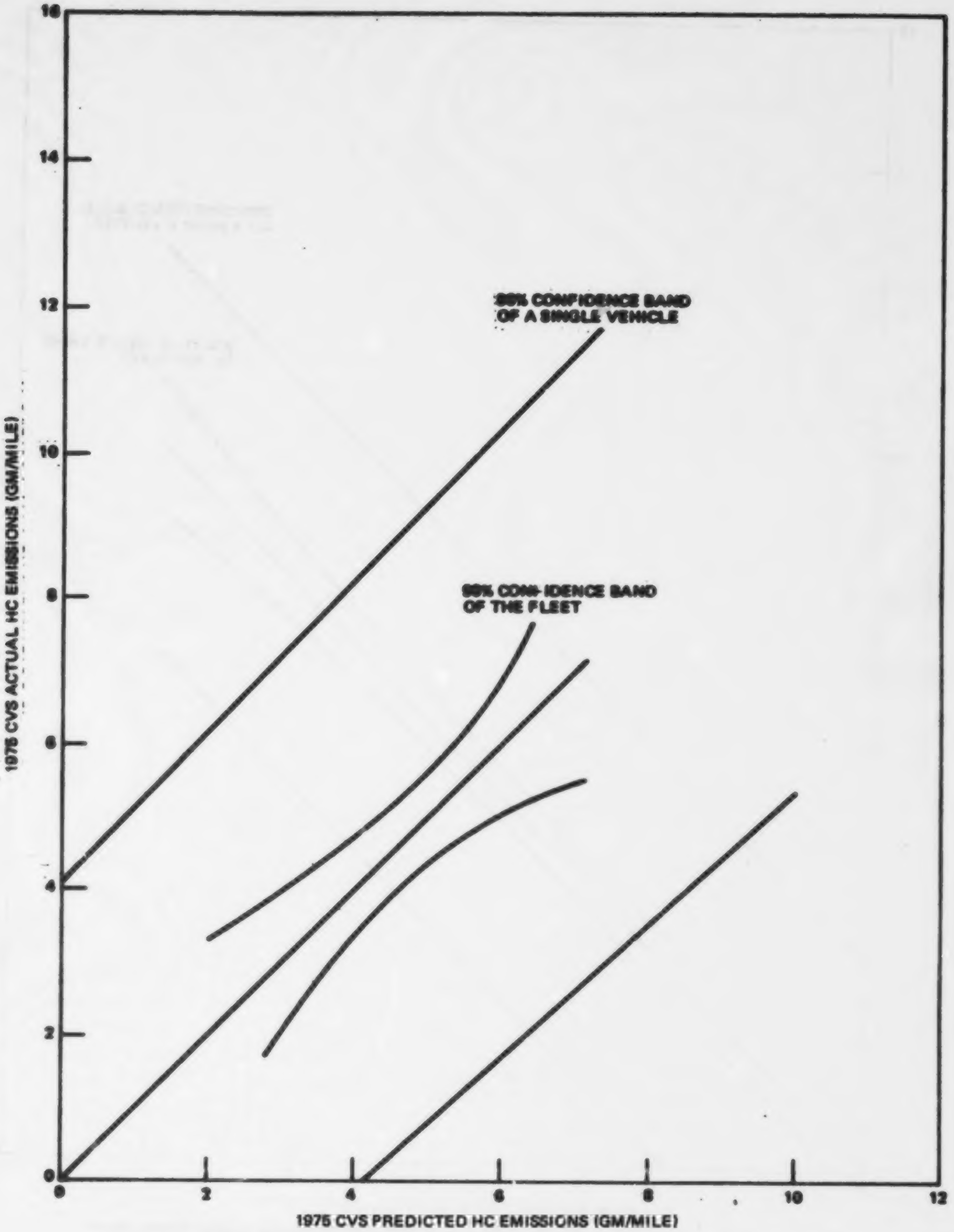


Figure 3-25. HC Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test – Phase I and II Controlled Vehicles

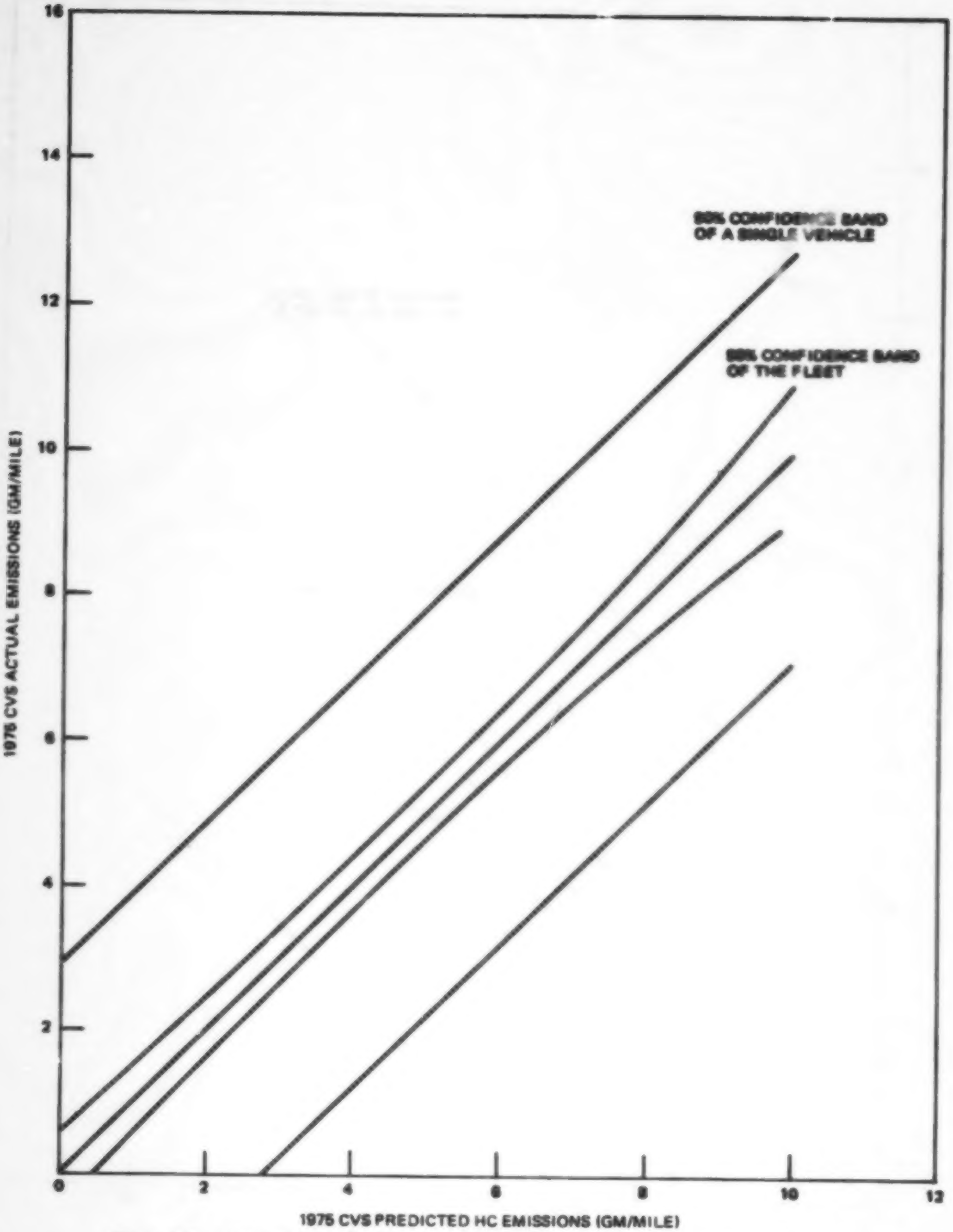


Figure 3-28. HC Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test – Phase I and II Controlled Vehicles

Reproduced from best available copy.

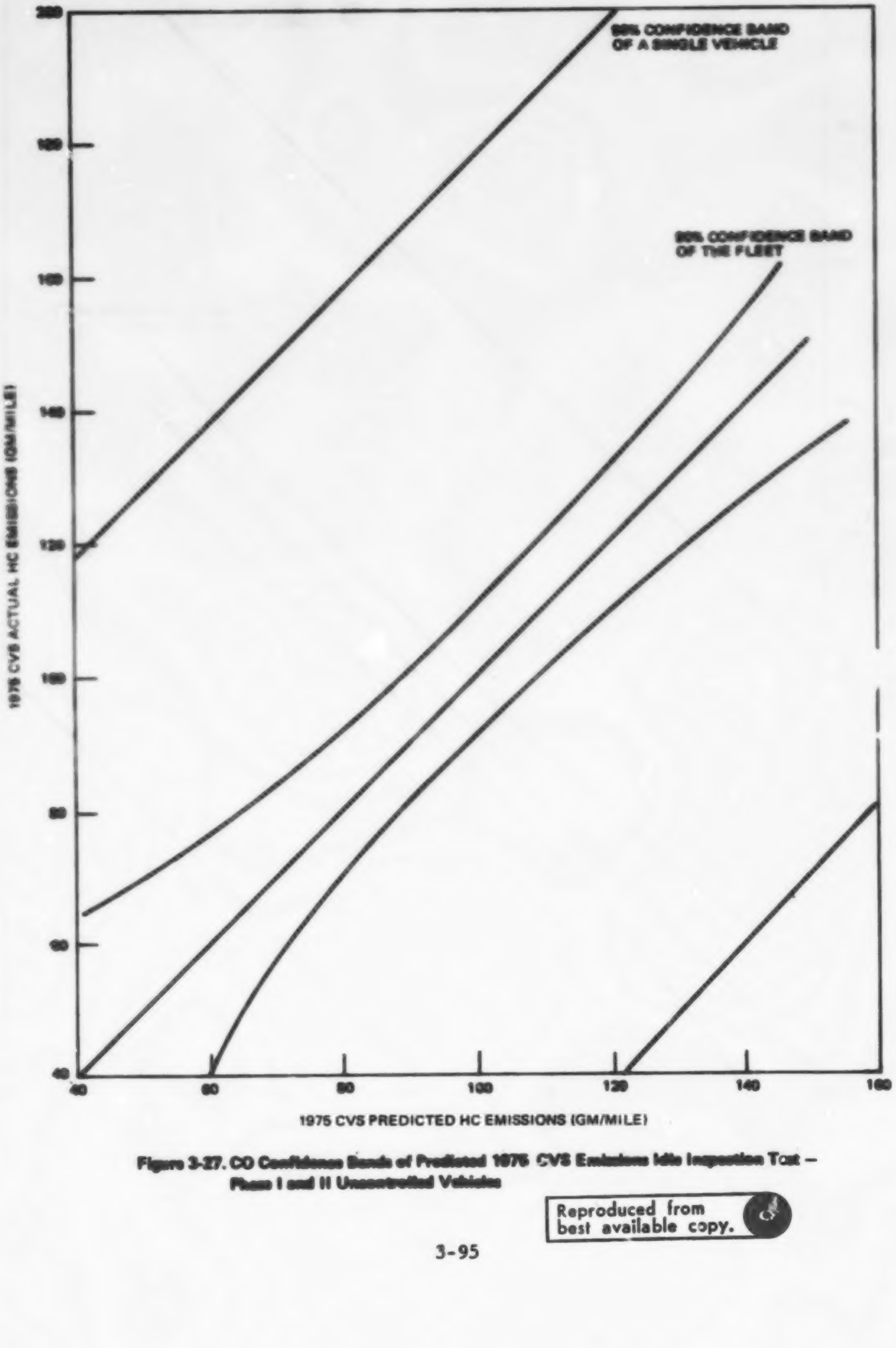


Figure 3-27. CO Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test – Phase I and II Uncontrolled Vehicles

Reproduced from
best available copy.

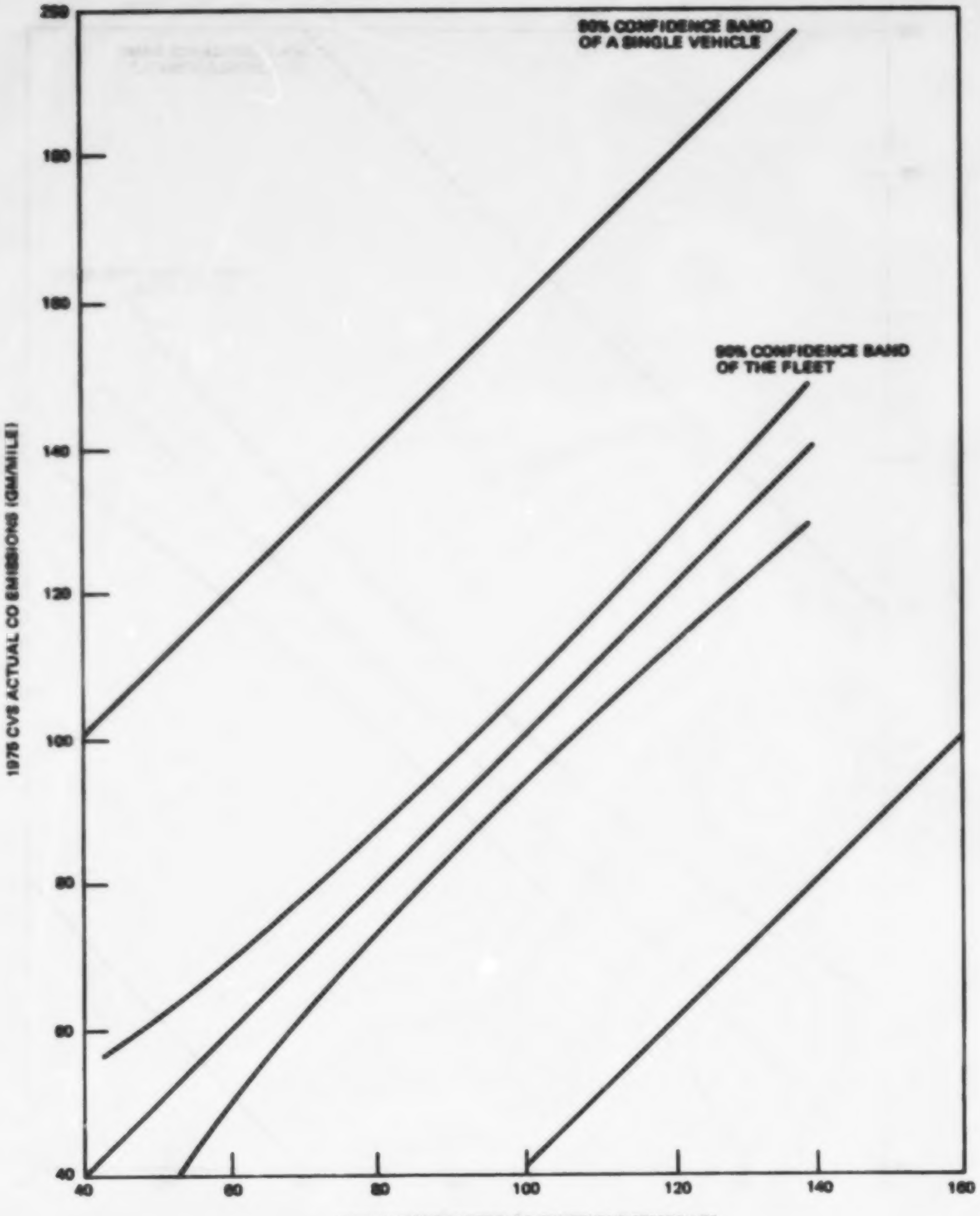


Figure 3-28. CO Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test – Phase I and II Uncontrolled Vehicles

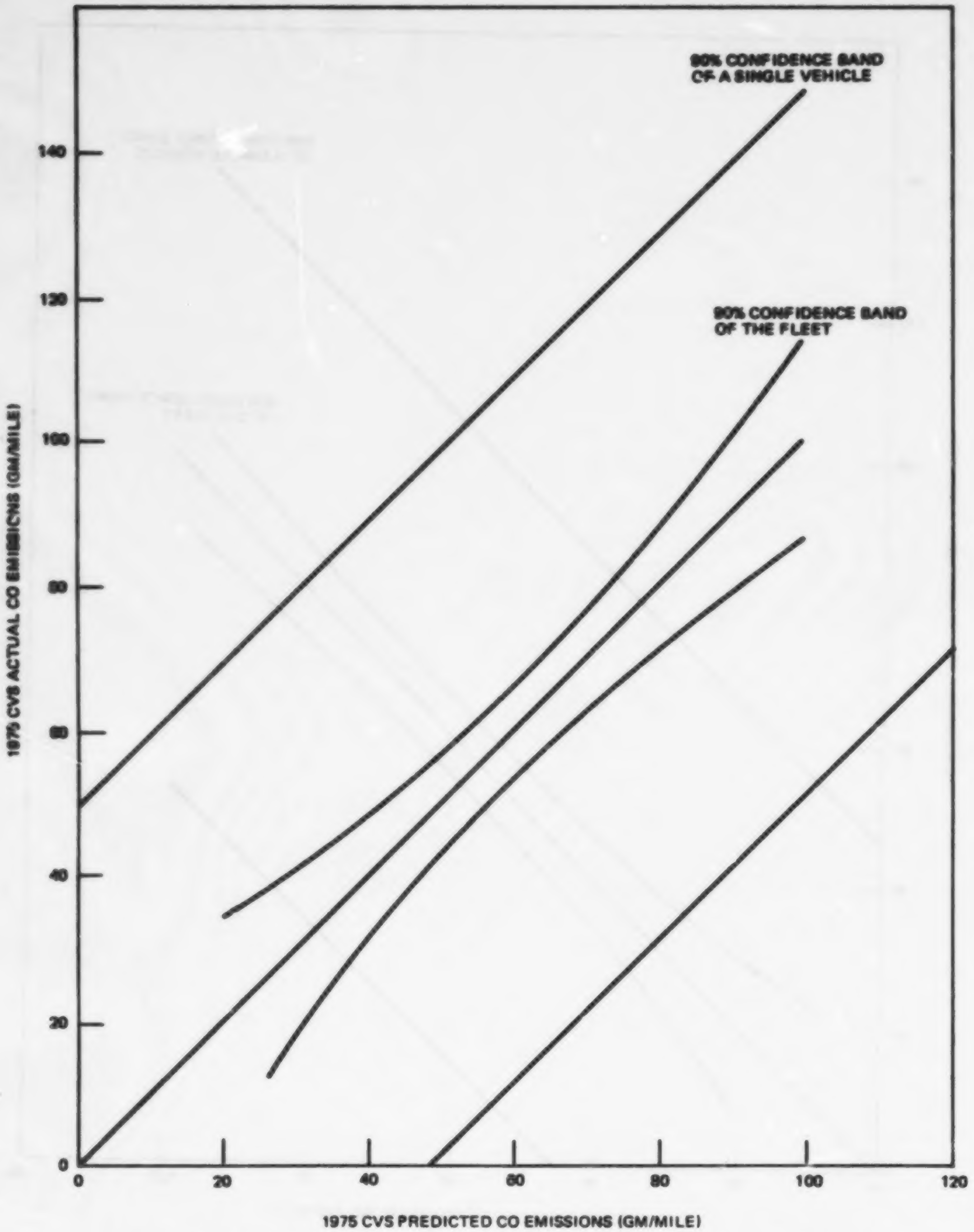


Figure 3-29. CO Confidence Bands of Predicted 1975 CVS Emissions Idle Inspection Test – Phase I and II Controlled Vehicles

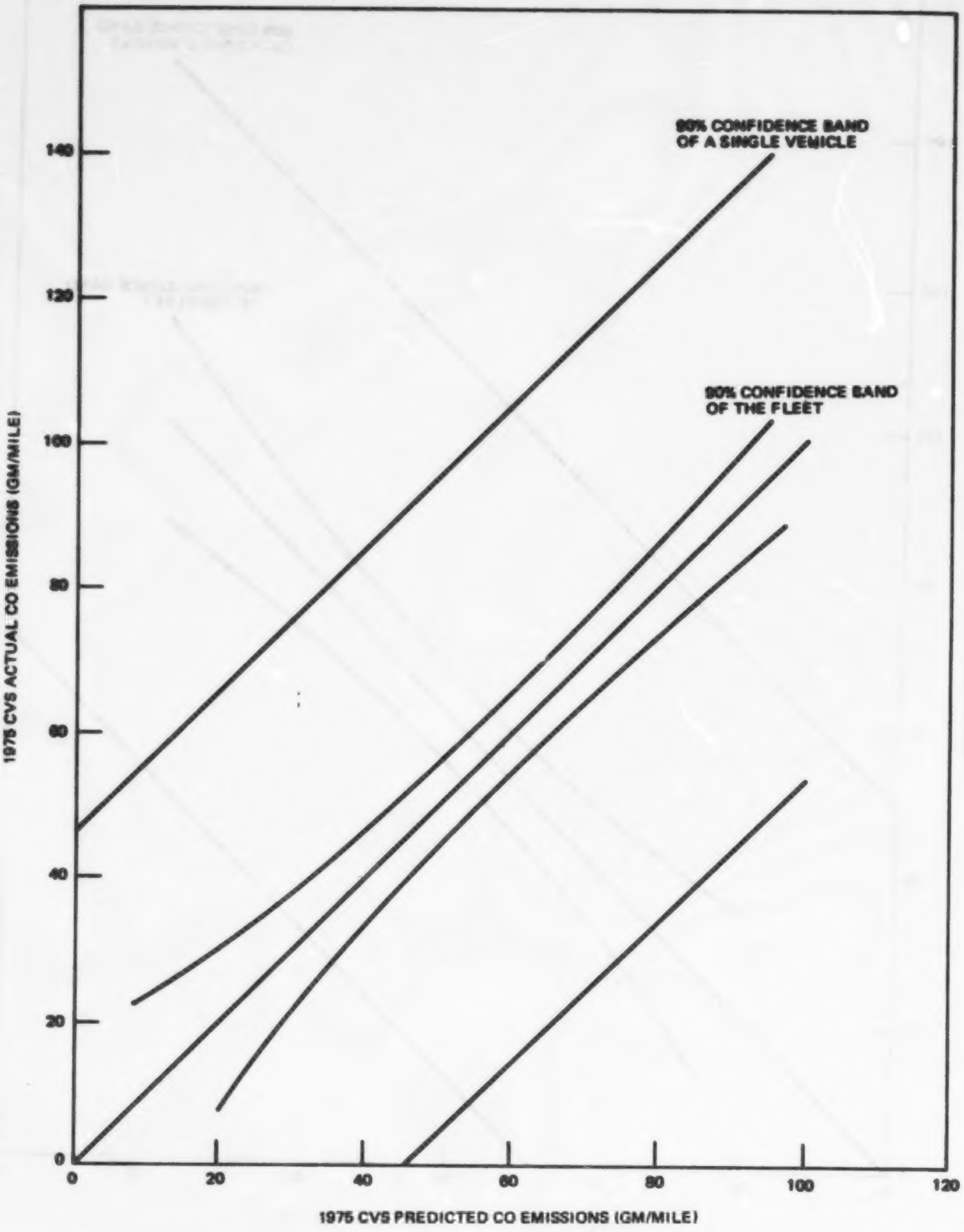


Figure 3-30. CO Confidence Bands of Predicted 1975 CVS Emissions Loaded Steady State Inspection Test – Phase I and II Controlled Vehicles

were both fairly good predictors of fleet 1975 CVS emission levels. Referring again to Figure 3-23 for Idle HC Emissions corresponding to a predicted 1975 CVS mean value of 12 grams per mile, there is 90% confidence the actual 1975 CVS fleet mean value was 10 to 13 grams per mile. For L.S.S. HC emissions, see Figure 3-24, corresponding to a predicted 1975 CVS fleet mean of 12 grams per mile, there is 90% confidence that the actual 1975 CVS fleet mean value was 11 to 13 grams per mile. In general, there was 90% confidence that the actual 1975 CVS fleet emission mean value was within plus or minus 20% of the 1975 CVS value predicted from both Idle and L.S.S. data.

The above analysis combined all vehicles. If separate correlations had been performed for different weight classes or if data had been adjusted for vehicle weight, a higher correlation might have been found.

3.6.2 Errors of Commission

Table 3-41 presents commission errors as a percentage of the total fleet when given proportions of each fleet are failed. For example, it is seen that at the 10% rejection rate for the California Idle Mode fleet 3% of all the controlled vehicles inspected were committed to unnecessary maintenance. As the rejection rate increased, the percentage of commission errors increased proportionally.

If commission errors of up to 10% of the fleet were acceptable, a failure rate no higher than between 20% and 30% of the total fleet would be accepted for HC. Similarly failure rate of between 30% and 40% of the total fleet would be acceptable for CO. In most cases, the uncontrolled vehicles exhibited larger fractions of commission errors than controlled vehicles for CO. This occurred due to the typically larger variance in the uncontrolled sample population.

The analysis shows that Idle and L.S.S. tests were essentially equal in the amount of commission errors caused. This was expected because of the similarity in the correlation coefficients and standard error of the tests. It was apparent, however, that there are fewer commission errors for CO than for HC measurements. For every commission error which occurs, an omission error also occurs. Omissions are caused when a vehicle which would have failed the 1975 test was passed because it showed low emissions on the short test. The result is that overall effectiveness in emission reduction is lower than would be the case if the 1975 CVS test were used. Since both Idle and L.S.S. have similar errors of commission, the lost effectiveness from errors of omission would also be similar.

An alternate definition of commission and omission errors can be proposed based upon the ability of the regime to identify correctable engine system malfunctions or maladjustments independent of CVS emission levels. Using malfunction detection rather than emission measurement as a goal, errors of commission and omission could be redefined as follows:

- errors of commission occur when the short inspection test fails vehicles that need no repair or cannot be repaired at reasonable cost;

Table 3-41

ANALYSIS OF ERRORS OF COMMISSION
Percent of All Inspected Vehicles

	RR	CALIFORNIA						MICHIGAN						COMBINED STATES					
		Idle			L.S.S.			Idle			L.S.S.			Idle			L.S.S.		
		C	U	T	C	U	T	C	U	T	C	U	T	C	U	T	C	U	T
HYDROCARBONS	10%	3	4	3	1	3	2	4	0	2	3	0	1	4	2	3	2	1	2
	20%	7	9	8	7	8	7	7	4	5	9	1	5	7	6	7	8	5	6
	30%	11	13	12	15	12	13	10	10	10	10	8	9	11	11	11	12	10	11
	40%	11	16	14	12	15	13	13	13	13	16	9	12	12	14	13	14	12	13
	50%	13	26	20	19	19	19	20	15	17	19	14	16	16	21	19	19	16	17
CARBON MONOXIDE	10%	1	1	1	0	0	0	0	4	2	1	1	1	1	3	2	1	1	1
	20%	1	4	3	3	4	3	0	6	3	3	3	3	1	5	3	3	3	3
	30%	6	8	7	5	5	5	4	10	7	4	4	4	5	9	7	5	5	5
	40%	11	11	11	9	7	8	10	16	13	7	11	9	11	14	12	8	9	9
	50%	14	18	16	12	9	10	14	25	20	11	13	12	14	21	18	12	11	11

C = Controlled Vehicles

U = Uncontrolled Vehicles

T = Combined Controlled and Uncontrolled Vehicles

RR = Percent of Vehicle Population Rejected by Inspection Test

- errors of omission occur when the short inspection test does not fail vehicles that can be repaired at reasonable cost

Using the above definition, L.S.S. was found to commit few errors of comission or omission compared to Idle when the service centers correctly utilized the diagnostic data available from the L.S.S. modal failures. Idle did not generally commit commission errors but did commit large numbers of omission errors because of low idle emissions but excessive power mode emissions.

REFERENCES

1. Final Report - "Mandatory Vehicle Emission Inspection and Maintenance," Volume III, California Air Resources Board Contract ARB 1522, 30 May 1971, by the Northrop Corporation, Environmental Systems Department.

2. Federal Register, Volume 35, Number 219, pp. 17288-17313.

3. Federal Register, Volume 36, Number 128, pp. 12657-12663.

4. Cline, E. L. and L. Tinkham, "A Realistic Vehicle Emission Inspection System," APCA Paper 68-152, Clayton Manufacturing Company, El Monte,, California.

5. Federal Register, Volume 33, Number 108, pp. 8304-8324.

6. Guenther, William. The Analysis of Variance: Prentice-Hall, Inc., 1964.

SECTION 4

APPENDICES

The three sections of the appendix consist of general information, 1975 CVS vehicle emission summary tables, and tables of short test regression and correlation coefficients. The regression and correlation summaries present data for Phase I and II combined. Emission summaries are presented separately for Phase I and II data.

4.1 APPENDIX A. TEST PROCEDURES

These procedures were supplied to the repair garages and provided the written instructions by which they inspected and repaired failing vehicles in the Idle and L.S.S. fleets.

4.2 APPENDIX B. VEHICLE EMISSION SUMMARY TABLES

The following tables present before service and after second service 1975 CVS emission data separately for Phase I and II. The tables present the number of vehicles, mean value, standard deviation, minimum value and maximum value for HC, CO and NO_x. Data are presented for the following vehicle parameters: age, mileage, make, control device, engine size and weight.

4.3 APPENDIX C. SHORT TEST REGRESSION AND CORRELATION SUMMARIES

The computer routine generated two types of regression program outputs: simple regression analysis (treating only one short test); and multiple stepwise regression analysis (treating more than one short test). The following paragraphs describe the data presented in each output. In the case of simple regression calculations, the two variables comprise the dependent (CVS) variable and the independent (short test) variable. In the case of multiple regressions, varying numbers of short test values comprise the independent variables and the CVS values comprise the dependent variable.

Reading across the summary tables from left to right, the following statistics are presented:

Name of Test - identifies each test which the 1972 and 1975 CVS tests were correlated and regressed against. The abbreviations for each of the tests are given in Table 4-1.

Z% - gives the expected plus and minus confidence band at 90% significance for the correlation coefficient (MR) in percent based on the sample size used (150 vehicles) if the coefficient were projected to a large (statewide) population. This statistic has no meaning for the multiple regressions and therefore are shown as zero. Z% is calculated from:

$$Z = \frac{1}{2} \ln \frac{1-MR}{1+MR}$$

Table 4-1 - SHORT TEST ABBREVIATIONS

EPA = Federal short cycle test - CVS bag mean value
M7MODE = 7-Mode hot start test - CVS bag mean value
KMIDLE = Multiple regression of three L.S.S. test modes - CVS diluted continuous measurement
M00MPH = 0 mph - CVS diluted continuous measurement
M10MPH = 10 mph - CVS diluted continuous measurement
M20MPH = 20 mph - CVS diluted continuous measurement
M30MPH = 30 mph - CVS diluted continuous measurement
M40MPH = 40 mph - CVS diluted continuous measurement
M50MPH = 50 mph - CVS diluted continuous measurement
M60MPH = 60 mph - CVS diluted continuous measurement
M-0MPH = Multiple regression of steady states test - CVS diluted continuous measurement
V7MODE = 7 Mode hot start test - NDIR continuous measurement
KVMIDL = Multiple regression of three L.S.S. test modes NDIR continuous measurement
V00MPH = 0 mph - NDIR continuous measurement
V10MPH = 10 mph - NDIR continuous measurement
V20MPH = 20 mph - NDIR continuous measurement
V30MPH = 30 mph - NDIR continuous measurement
V40MPH = 40 mph - NDIR continuous measurement
V50MPH = 50 mph - NDIR continuous measurement
V60MPH = 60 mph - NDIR continuous measurement
V-0MPH = Multiple regression of steady states test - NDIR continuous measurement

---

NOTES: (1) The first 11 tests determine emissions in mass units of either grams per mile or grams per min.

(2) The last 10 tests determine emissions in concentration units of either ppm or percent.

A - intercept of the simple regression line, i.e. the value which would be predicted for the dependent variable (CVS test) if the independent variable (short test) were measured at zero.

B1 thru B7 - slope of the regression line between the dependent and independent variable(s), i.e. the ratio of the dependent to independent variable(s). Only B1 is necessary for the simple regression. For multiple regressions, B1 represents 0 mph, and B2 thru B7 represent 10 thru 60 mph respectively. For L.S.S. B1, 2, and 3 are associated with Idle, Low Cruise, and High Cruise respectively. The value will be shown as zero if the variable exhibits little or no correlation with the CVS values.

AL% and BL% - shows the expected plus and minus confidence band at 90% significance for the A and B parameters respectively based on the sample size used. These statistics have no meaning for the multiple regressions and therefore are shown as zero. AL% and BL% are calculated from:

$$AL = \frac{1}{2} \ln \frac{1-A}{1+B} \qquad BL = \frac{1}{2} \ln \frac{1-B}{1+B}$$

F - The F-ratio value which was computed to test the hypothesis that the slope of the regression line was non-zero, i.e. that there in fact existed a relationship between the short test values and the CVS values. High F-ratios indicate significant relatability between the tests. The F-ratio value is also used by the stepwise multiple regression program to determine if a newly added variable provides a significant increase in correlation. The F-ratio value is calculated from:

$$F = \frac{MSR}{SE^2}$$

where MSR is the mean square due to regression

$$\text{ie. } MSR = b \left[\Sigma x_i \, y_i - \frac{\Sigma xi \;\; \Sigma yi}{n} \right]$$

and SE is defined below

SE - the standard error of the estimated regression shows the "closeness" of the relationship between the two variables. The smaller the standard error, the more accurate the predictions of the dependent (CVS) values based on the short test and the regression equation. In other words, actual values of the dependent variable become closer to the regression line as the standard error decreases. The standard error is calculated from:

$$SE^2 = \frac{1}{n-2} \sum_{i=1}^{n} \left[y_i - (a + bx_i) \right]$$

MR - coefficient of (multiple) regression; synonymous with the correlation coefficient. This parameter shows how well the dependent and independent variables are related. The square of the MR (times 100%) indicates that percentage of the dependent variable's variation which is explainable by variations in the independent variable. MR is calculated from:

$$MR = \frac{\Sigma(x_1 - \bar{x})\ (y_1 - \bar{y})}{\left[\Sigma(x_1 - \bar{x})^2\right]^{\frac{1}{2}} \left[\Sigma y_1 - \bar{y})^2\ ^{\frac{1}{2}}\right]}$$

APPENDIX A-1

IDLE REPAIR FACILITY PACKET

This package contains the following information regarding the IDLE TEST PROCEDURES:

1) Introductory Letter
2) IDLE EMISSIONS, ADJUSTMENT, AND REPAIR PROCEDURES
3) Sample Repair Reports

Olson Laboratories, Inc.
500 E. ORANGETHORPE AVENUE, ANAHEIM, CALIF. 92801
TELEPHONE: (714) 871-3920, TELEX: 65-5417

October 20, 1971

Dear Sir:

On behalf of Olson Laboratories, I welcome you as a participating service center in this program to reduce automotive air pollution. You are participating in a test program to determine the best way to reduce exhaust emissions from automobiles presently on the road. It is well known that a properly tuned engine emits less unburned gasoline and carbon monoxide than an out-of-tune engine. This means that the automobile repair industry has an important roll in helping to reduce air pollution.

During this program, two methods of identifying and correcting maladjusted and malfunctioning cars will be compared. You will participate as an IDLE MODE GARAGE using your diagnostic equipment and skill plus an additional tool, the Olson-Horiba Mexa 300 HC/CO instrument, to identify and repair malfunctioning vehicles. Olson Laboratories will use the Federal new-car emission test procedure to determine how much the emissions of HC and CO were reduced.

Briefly summarizing your part in the program, the following points should be kept in mind:

1) The Olson-Horiba Mexa 300 HC/CO instrument, your diagnostic equipment and the enclosed pamphlet should be used in adjustment and repair actions.

2) Adjust or repair the vehicles as you normally would so that emissions are equal or less than the appropriate standard. Major overhauls such as ring and valve jobs are not to be performed without prior authorization from Olson Laboratories. Attempt all adjustments before replacement or repair action is taken.

3) Cost should be itemized on an invoice and accompany the repaired car when returned to Olson Laboratories.

4) Blank repair action forms will be given to you which should be filled out by the mechanic working on the vehicle.

5) 10-15 cars will be assigned to your garage through December 20.

6) Vehicles will be picked up and delivered by Olson Laboratories' employees.

Sincerely yours,

Richard R Carlson

Richard R. Carlson
Project Engineer

IDLE EMISSION TEST, ADJUSTMENT, AND REPAIR PROCEDURE

FOR

PARTICIPATING GARAGES

The following test, adjustment, and repair procedure is recommended to bring the vehicle within prescribed emission levels. Only those adjustments or repair actions required to correct Idle emissions are to be performed. Use attached data sheet to record emission measurements.

A. PRE-TEST

Prepare vehicle and equipment for test.

1. Test Equipment - Service, warm-up, and calibrate Olson-Horiba Mexa 300 HC/CO test equipment per manufacturer's specifications.
2. Test Vehicle - Verify engine is at normal operating temperature (warm-up as required).
3. Hook-Up - Insert probe in exhaust pipe (opposite side of heat riser if dual exhaust), hook-up tachometer per manufacturer's instructions.

B. TEST

1. Idle RPM - Perform HC/CO and RPM measurements and compare to Idle Test Standards.
2. 2500 RPM - Operate engine in neutral at 2500 RPM to clean out engine.
3. Idle RPM - Operate engine at Idle RPM (in drive if automatic transmission), record measurements.
4. Compare - Idle RPM emissions to test standards and record manufacturer's specified RPM; if HC or CO is high, adjust per Step C. If HC and CO are within limits return vehicle to Olson Laboratories, Inc.

C. ADJUST

Perform engine adjustments for HC/CO.

Note: When any adjustment step brings emissions within limits STOP procedure at that point and re-test per Step B.

Adjustment Procedure

1. RPM - Adjust (if required) to manufacturer's specifications; recheck HC and CO and record.

2. HC - Check timing per manufacturer's procedure and record. If timing is not at manufacturer's specification, adjust as required; re-adjust RPM, if required; re-check HC/CO and record.

3. CO

   (a) Adjust Idle mixture to manufacturer's specification. Where no specifications are available use: 2.0 to 5.0% CO for uncontrolled vehicles and 1.0 to 4.0% CO for controlled vehicles. Re-adjust RPM, if required.

   Note: When adjusting Idle CO, attempt to reduce CO to lowest possible value, consistent with good Idle quality. Avoid a rough Idle condition, side to side unbalance or increase in HC (HC increase indicates a lean idle misfire).

   If CO/HC emissions cannot be reduced to within limits, while maintaining acceptable Idle quality; diagnose and repair (Step D) vehicle as required. ONLY those repairs necessary to bring Idle HC/CO within limits are to be accomplished.

   (b) After adjustment, enrichen mixture slightly to avoid too lean a condition. Recheck HC/CO and record.

D. REPAIR

Diagnose and repair engine; when repair is complete re-test per Step B.

1. Diagnose Engine.
2. Repair malfunction per manufacturer's specifications.
3. Re-test per Step B, record measurements.
4. If emission limits cannot be achieved within the following repair constraints imposed by Olson Laboratories, contact Olson Laboratories immediately for disposition of vehicle.

HELPFUL HINTS

High HC - Indications are caused by ignition misfires, advanced ignition timing, exhaust valve leakage, and over-lean mixtures. Ignition misfires can be diagnosed by use of the oscilloscope. Timing problems by use of timing light. Valve failure is indicated by cylinder balance testing with compression test verification. Lean misfire is caused by too lean Idle mixture setting or manifold vacuum leaks.

High CO - Can be caused by abnormally restricted air cleaner, stuck or partially closed choke or carburetor Idle circuit failure. Rough or erratic Idle can be caused by PCV valve malfunction. Idle HC/CO failure/malfunction Truth Table can be used as a guide to identifying failures.

MALFUNCTION TRUTH TABLE

Malfunction	HC		CO		Rough Idle
	High	Very High	High	Very High	
PCV Valve Dirty/ Restricted			X		X
Air Cleaner Dirty/ Restricted			X	X	
Choke Stuck Partially Closed				X	
Carburetor Idle Circuit Malfunction	X		X		X
Intake Manifold Leak	X	X			X
Ignition Timing Advanced	X				
Leaky Exhaust Valves	X	X			X
Ignition System Misfire	X	X			X

OLSON LABORATORIES, INC.
A Subsidiary of Northrop Corporation

IDLE INSPECTION DATA SHEET

Car Number:_______ License Number:_______ Test Date:_________

PCV ☐ Engine Mod. ☐ Air Injection ☐ R/T_____

MINOR ADJUSTMENTS:	IDLE RPM	IDLE TIMING	IDLE DWELL	IDLE CO	IDLE HC
FACTORY:					
STEP B: AS RECEIVED:					
STEP C: RESET:					

STEP D: Repair vehicle using Helpful Hints in Repair Facility Packet. Indicate repairs performed on invoice. After repairs are completed, retest vehicle for HC and CO. Readjust idle adjustment if required. The HC and CO readings must be lower than the factory limits indicated for Idle CO and HC.

FINAL IDLE ADJUSTMENT:	IDLE RPM	TIMING	DWELL	MIXTURE (CO)	HC

REMARKS:____

500 East Orangethorpe Avenue · Anaheim, California 92801 · Telephone 714 871-3920 · Telex 65-5417

APPENDIX A-2

KEY MODE REPAIR FACILITY PACKET

This package contains the following information regarding the KEY MODE TEST PROCEDURES:

1) Introductory Letter
2) Clayton Manufacturing Co. KEY MODE TRUTH CHART BOOKLET
3) Sample Key Mode Report Cards
4) Sample Repair Reports

Olson Laboratories, Inc.

500 E. ORANGETHORPE AVENUE, ANAHEIM, CALIF. 92801
TELEPHONE: (714) 871-3920, TELEX: 65-5417

October 25, 1971

Dear Sir:

On behalf of Olson Laboratories, I welcome you as a participating service center in this program to reduce automotive air pollution. You are participating in a test program to determine the best way to reduce exhaust emissions from automobiles presently on the road. It is well known that a properly tuned engine emits less unburned gasoline and carbon monoxide than an out of tune engine. This means that the automobile repair industry has an important role in helping to reduce air pollution.

During this program, two methods of identifying and correcting maladjusted and malfunctioning cars will be compared. You will participate as a KEY MODE GARAGE using your diagnostic equipment and skill plus the additional tools of Clayton Key Mode Truth Charts and an Olson-Horiba Mexa-300 HC/CO instrument, to identify and repair malfunctioning vehicles. Olson Laboratories will use the Federal new-car emission test procedure to determine how much the emissions of HC and CO were reduced.

Briefly summarizing our part in this program, the following points should be kept in mind:

1) The Key Mode Truth Charts which will be sent to you with each car, and the enclosed pamphlet should direct your repair actions.

2) The Olson-Horiba Mexa-300 HC/CO instrument, which will be loaned to you for this program, should be used to help make adjustments and repairs.

3) Adjust or repair vehicles as directed by the Key Mode Truth Charts so that emissions are minimized except that major overhauls such as ring and valve jobs are not to be performed without prior authorization from Olson Laboratories. Attempt all adjustments before replacement or repair action is taken.

4) Costs should be itemized on an invoice and accompany the repaired car when returned to Olson Laboratories. Two copies of the invoice should be sent.

5) Blank repair action forms will be given to you which should be filled out by the mechanic working on the vehicle. The repair action form will carry the failure limits for CO and HC which should not be exceeded.

6) 10-15 cars will be assigned to your garage through December 20th.

7) Vehicles will be picked up and delivered by Olson Laboratories' employees.

Sincerely yours,

Richard R Carlson

Richard R. Carlson
Project Engineer
(714) 871-5000
Extension 1087 or 427

RRC/jm

REVISED KEY MODE TEST, ADJUSTMENT, AND REPAIR PROCEDURE

FOR

PARTICIPATING GARAGES

The following test, adjustment, and repair procedure is recommended to bring the vehicle within prescribed emission levels. Only those adjustments or repair actions suggested by the Clayton Truth Charts are to be performed. Do not attempt to make repairs which are not called for by the Truth Charts. Use attached data sheet to record emission measurements.

A. Examine Truth Charts when vehicle is received.

1. If Truth Table indicates an idle failure for HC or CO, proceed with remaining procedure beginning with step B.

2. If Truth Tables indicate a failure for HC or CO in either LO Cruise and/or HI Cruise, perform the work suggested by the Truth Tables. Then proceed with step B.

B. Pre-Test

Prepare vehicle and equipment for test.

1. Test Equipment - Service, warm-up, and calibrate Olson-Horiba Mexa-300 HC/CO test equipment per manufacturer's specifications.

2. Test Vehicle - Verify engine is at normal operating temperature (warm-up as required).

3. Hook-up - Insert probe in exhaust pipe (Opposite side of heat riser if dual exhaust), hook-up tachometer per manufacturer's instructions.

C. Test

1. Operate engine in neutral at 2500 RPM to clean out engine

2. Idle RPM - Operate engine at Idle RPM (in drive if automatic transmission), record measurements.

3. Compare - Idle RPM emissions to test standards and record manufacturer's specified RPM,timing and dwell. If Idle HC or CO is high, adjust per step D.

D. Adjust

Perform engine timing, dwell and RPM adjustments and measure HC/CO. Dwell and timing should be at manufacturer's specifications. RPM may be as much as 50 RPM greater than specifications.

NOTE: When any adjustment step brings emissions within limits STOP procedure at that point and retest per step C.

OLSON LABORATORIES, INC.
A Subsidiary of Northrop Corporation

INITIAL KEY MODE DATA SHEET

KEY MODE REPORT CARD

CAR NUMBER__________ YEAR__________ CONTROLLED ☐

	IDLE	LOW CRUISE	HIGH CRUISE
- CO - CARBON MONOXIDE	3.0%	2.5%	2.0%
- HC - UNBURNED HYDROCARBON	290ppm	240ppm	220ppm

✓ = REJECT

After final repair or adjustment, insure that the following adjustments are within manufacturer's specification.

	IDLE RPM	IDLE TIMING		IDLE DWELL	IDLE CO	IDLE HC
FACTORY SPEC.			TDC			
RESET						

COMMENTS: ______________________________

____

REVISED KEY MODE DATA SHEET

CLAYTON KEY MODE TRUTH CHART

Uncontrolled

CAR NUMBER ________________ YEAR __________ LICENSE ___________

	IDLE	LOW CRUISE	HIGH CRUISE
- CO - CARBON MONOXIDE	5.5%	3.5%	3.0%
- HC - UNBURNED HYDROCARBON	700ppm	450ppm	450ppm

This vehicle was tested by Olson Laboratories and failed the Clayton Key Mode emission test during the modes indicated by a check (✓). The actual values measured have been written in each box. The values which a properely functioning car would have are printed in each box. Use the Clayton pamphlet by finding a sample truth chart checked like this one and perform the work suggested. Attempt adjustments first. Record test results on the Garage Repair Report and your invoice. After final repair insure that basic idle adjustments are within manufacturer's specification and that emission values at idle are within the limits written on the Garage Repair Report.

TRUTH CHARTS

(For Use In Conjunction With The Inspection Report Card Of
The Key Mode Emission Evaluation And Repair System)

IMPORTANT: Read the Introduction and Chart Usage before attempting to use the Truth Charts.

INTRODUCTION

The Key Mode System operates the engine in carefully selected modes that have been found to most reliably cause emission related engine malfunctions to occur. Abnormal gas content indicates the presence of a malfunction. The mode or modes in which they occur are indications of the type of malfunctions or maladjustments.

The Truth Charts are designed as an aid to mechanics in determining the type of malfunction that is causing unnecessarily high exhaust emission. They will direct the mechanic's attention to the mode of engine operation in which the fault exists, and indicate the malfunctioning system that needs repair or adjustment.

The mechanic must understand the fundamental causes of unnecessarily high Carbon Monoxide (CO) and Hydrocarbons (HC) if he is to be effective in repairing engines to reduce exhaust emissions. Engine exhaust emission is a new parameter to practically all mechanics.

The fundamental difference between causes of high CO and high HC is as follows:

CARBON MONOXIDE (CO)

CO is a result of incomplete combustion. That is, the gas must be subjected to combustion in order to form CO. If the mixture is too rich, there is insufficient Oxygen (O_2) to complete the combustion, thus large amounts of CO result instead of the optimum condition of Carbon Dioxide (CO_2) formation. There will always be at least a small amount of CO in the exhaust because perfect combustion is not to be expected. Abnormally high CO can only be due to excessively rich Air/Fuel mixture.

INTRODUCTION (Cont'd)

HYDROCARBON (Gasoline is essentially 100% Hydrocarbon)

A modest amount of HC will always be present in the exhaust gas. This is a result of both incomplete combustion and fuel at the flame boundries that has not been fully subjected to combustion. When CO is normal and grossly high HC is present, an abnormal amount of raw fuel is escaping from the combustion chamber without being subjected to combustion. This is generally due to ignition misfire or leaking exhaust valves. Moderate rise in HC can result from early ignition timing, preignition causing abnormal flame propagation, or Air/Fuel mixture being too lean to consistently support combustion.

High HC and CO may exist in any one mode of engine operation, any combination of two modes or in all modes. A basic knowledge of these patterns and their meaning is important.

TRUTH CHART USAGE

The master Truth Charts, pages 8 to 14, show reject patterns resulting from various types of malfunction or maladjustment. When a test report is received on a vehicle, its reject boxes (✓) act as a repair guideline for the servicing agency by comparing it to a similar master Truth Chart. The mechanic will quickly learn to diagnose without the example cards if he remembers the fundamental difference between causes of high CO and HC, and understands the engine operating conditions represented by the Idle, Low Cruise, and High Cruise boxes of the Report Card.

The Idle Mode, as its name implies, is with normally closed throttle, thus the engine is operating at or near the conditions where basic engine adjustments are made. The high intake manifold vacuum at idle or at higher free-running engine speeds result in a relatively low compression pressure in which the spark plug fires.

TRUTH CHART USAGE (Cont'd)

The High Cruise Mode tests the engine at a point where the intake manifold vacuum is down, thus compression pressure is up. The air flow through the carburetor has increased so that the main jet system of the carburetor is in full operation. Speed and vacuum signals have changed the ignition advance. In other words, it provides dynamic test data to expose malfunctioning engine systems that are not responding properly to the signals from increase in speed and air flow.

The Low Cruise Mode is in the transition range of speed and power between Idle and High Cruise. As a general statement, the carburetor is blending the idle and main jet fuel supply. Also, with only a modest ignition advance due to speed, the vacuum advance is at or approaching maximum. Compression pressures have increased moderately from idle conditions. Engines that "stumble" or otherwise malfunction as they come off idle, are most likely to be exposed at this "mid-power, mid-speed" point.

> NOTE: The Key Mode Truth Chart can be used with all internal combustion gasoline engines. For simplicity, the numbers have been left out of the Truth Charts. Make repair based on those boxes which have been checked (✓).

EXAMPLE REPORT CARDS

(Pages 5 and 6)

The two following example Report Cards are similar to the Report Card that will be received from the inspecting agency.

The upper numbers in each box of the Report Card indicate the "Sensible Maximum" values for that type of vehicle when it is in good repair and adjustment. These values are intended as guidelines for the repairing agency.

The lower numbers are the actual values derived from dynamic test of the vehicle.

The actual values used for reject of the vehicle are not printed on the Report Card, but are usually considerably higher than the "Sensible Maximum." Repair must be made based only on the rejects (✓).

Example Report Card - Page 5

Note the "Sensible Maximum" in the upper half of each box, and the larger actual values at the bottom.

For repair of this vehicle, the mechanic would find that the second example on Truth Chart #2 matches his Report Card, and would repair accordingly.

Example Report Card - Page 6

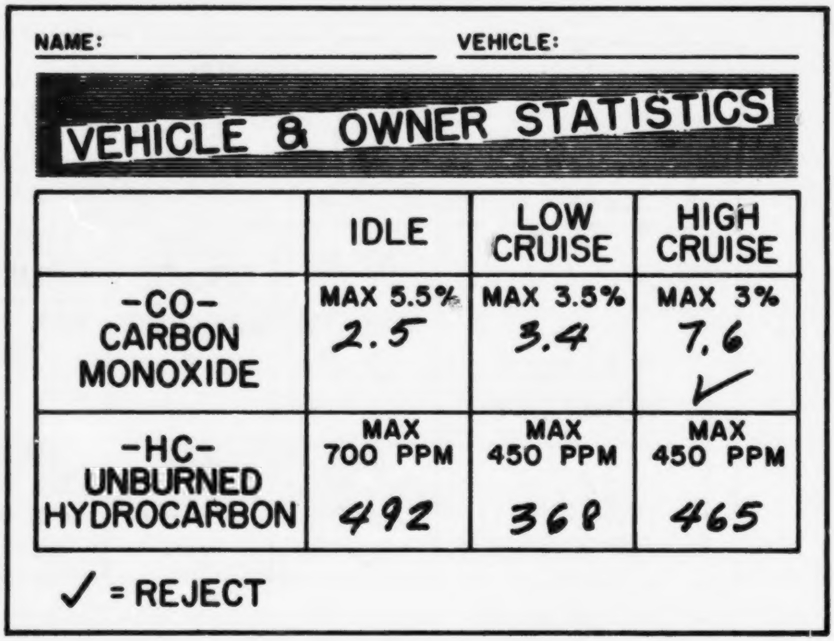
Note the "Sensible Maximum" in the upper half of each box. These values are lower than in the previous Report Card because this is an emission control vehicle and is capable of lower emissions when in proper operating order.

Also, note that the Idle CO is higher than the "Sensible Maximum," but is not rejected. This is because it was not high enough to be rejected by the actual reject values of the inspecting agency.

For repair of this vehicle, the mechanic would find that the second example on Truth Chart #6 matches his Report Card, and would repair accordingly.

TYPICAL REPORT CARD

NON-EXHAUST EMISSION CONTROLLED



NAME: ______________ **VEHICLE:** ______________

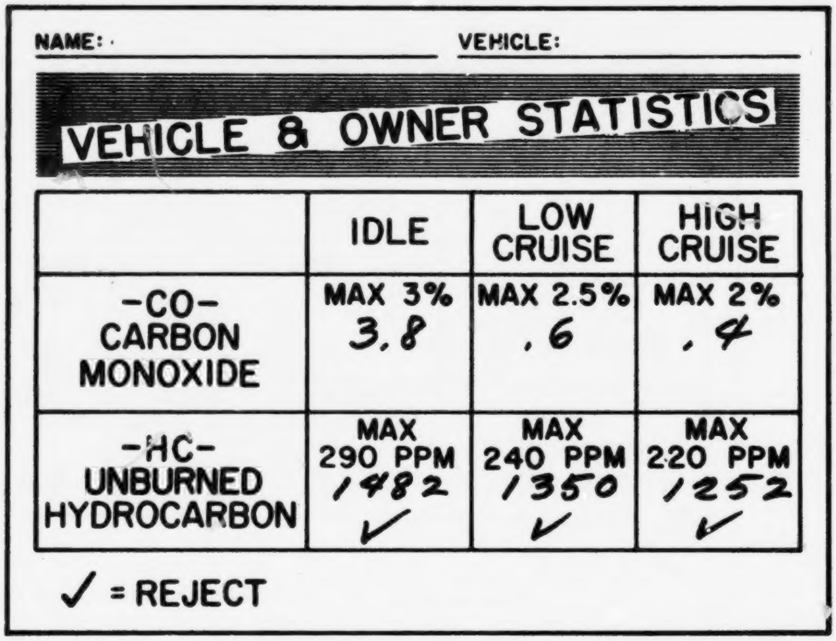
VEHICLE & OWNER STATISTICS

	IDLE	LOW CRUISE	HIGH CRUISE
-CO- CARBON MONOXIDE	MAX 5.5% 2.5	MAX 3.5% 3.4	MAX 3% 7.6 ✓
-HC- UNBURNED HYDROCARBON	MAX 700 PPM 492	MAX 450 PPM 368	MAX 450 PPM 465

✓ = REJECT

TYPICAL REPORT CARD

EXHAUST EMISSION CONTROLLED



NAME:

VEHICLE:

VEHICLE & OWNER STATISTICS

	IDLE	LOW CRUISE	HIGH CRUISE
-CO- CARBON MONOXIDE	MAX 3% 3.8	MAX 2.5% .6	MAX 2% .4
-HC- UNBURNED HYDROCARBON	MAX 290 PPM 1482 ✓	MAX 240 PPM 1350 ✓	MAX 220 PPM 1252 ✓

✓ = REJECT

CARBON MONOXIDE

Basic problems involved ONLY with carburetor misadjustments or malfunctions.

Refer to these Charts for assistance in diagnosing problems where one or more of the top three boxes has been checked with a reject (✓).

CHART #1

	IDLE	LOW CRUISE	HIGH CRUISE
CO	✓		
HC			

ABNORMALLY HIGH IDLE CO

	IDLE	LOW CRUISE	HIGH CRUISE
CO	✓	✓	
HC			

ABNORMALLY HIGH IDLE CO CARRYING OVER TO LOW CRUISE

USUAL CAUSE

1. Gross error in carburetor idle air fuel mixture adjustment.
2. Rarely high idle CO carries over into Low Cruise, as shown in the second example.

SERVICE STEPS

1. Inspect the PCV system to insure it is clean and operating correctly. A PCV system malfunction can cause erratic idle operation.
2. Make basic engine idle adjustments of ignition dwell and timing, idle speed and air fuel ratio.

   CAUTION: After making the basic idle adjustment, accelerate the engine at least three times and let it return to idle. Observe the stability and repeatability of idle condition.
3. In rare cases that idle adjustments cannot be made correctly, due to excessive amounts of varnish or foreign deposits in the carburetor idle passages, it may be necessary to replace or repair the carburetor.

CHART #2

	IDLE	LOW CRUISE	HIGH CRUISE
CO		✓	
HC			

ABNORMALLY HIGH CO AT LOW CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO			✓
HC			

ABNORMALLY HIGH CO AT HIGH CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO		✓	✓
HC			

ABNORMALLY HIGH CO AT LOW AND HIGH CRUISE

USUAL CAUSE

The most common cause is a main system carburetor malfunction. This problem cannot be corrected by an Idle adjustment only.

SERVICE STEPS

1. Check carburetor air cleaner for abnormal restriction.
2. Check to see that choke is not stuck partially closed.
3. If the air cleaner and choke are satisfactory, remove the carburetor and replace or repair according to factory specifications.

   NOTE: If carburetor rebuild is undertaken, refer to the carburetor check sheet, page 17 of this manual.

ALWAYS MAKE THE BASIC IDLE ADJUSTMENTS OF IGNITION DWELL AND TIMING, IDLE SPEED AND AIR FUEL RATIO, TO COMPLETE THE REPAIR.

CHART #3

	IDLE	LOW CRUISE	HIGH CRUISE
CO	✓		✓
HC			

ABNORMALLY HIGH CO AT IDLE AND HIGH CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO	✓	✓	✓
HC			

ABNORMALLY HIGH CO IN ALL MODES OF OPERATION

USUAL CAUSE

A combination of a malfunctioning carburetor main system and a maladjusted idle air fuel ratio.

SERVICE STEPS

1. Refer to Chart #2. The main system malfunction should obviously be corrected first.
2. Idle CO will be corrected when basic adjustments are made.

ALWAYS MAKE THE BASIC IDLE ADJUSTMENTS OF IGNITION DWELL AND TIMING, IDLE SPEED AND AIR FUEL RATIO, TO COMPLETE THE REPAIR.

UNBURNED HYDROCARBON

Basic problems involved ONLY with ignition misfires, vacuum leaks, valve leaks, ignition timing, or any condition which will permit raw fuel to escape into the exhaust pipe without being subjected to combustion.

Refer to these charts for assistance in diagnosing problems where one or more of the bottom three boxes has been checked with a reject (✓).

CHART #4

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC	✓		

ABNORMALLY HIGH HC AT IDLE

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC	✓	✓	

ABNORMALLY HIGH HC AT IDLE CARRYING OVER TO LOW CRUISE

USUAL CAUSES

1. Vacuum leaks into the intake manifold causing a lean mixture and subsequent misfire in some cylinders.
2. Idle circuits on 2 and 4 barrel carburetors highly imbalanced or adjusted too lean.
3. Intermittent ignition misfire is possible but not probable.
4. Grossly advanced basic ignition timing.
5. Modest compression leak through one or more exhaust valves.

SERVICE STEPS

1. Note idle CO on Report Card and determine that idle is not adjusted too lean (less than 1.0% CO).
2. Ignition misfire at idle and not in the power modes is uncommon; however, simplicity of oscilloscope check-out suggests this be observed next.
3. Determine that basic ignition timing is not grossly advanced.
4. Check for balanced idle adjustments if 2 or 4 barrel carburetor.
5. Check for vacuum leaks into the intake manifold.
6. If above steps do not locate the source of trouble, make a cylinder compression check. Burned exhaust valves can cause up to four times normal HC at Idle, with little increase in the Cruise modes.

ALWAYS MAKE THE BASIC IDLE ADJUSTMENTS OF IGNITION DWELL AND TIMING, IDLE SPEED AND AIR FUEL RATIO, TO COMPLETE THE REPAIR.

CHART #5

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC		✓	

ABNORMALLY HIGH HC AT LOW CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC			✓

ABNORMALLY HIGH HC AT HIGH CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC		✓	✓

ABNORMALLY HIGH HC AT LOW AND HIGH CRUISE

USUAL CAUSES

Ignition misfire under higher compression pressures of power operation, due to a failure of an ignition system component.

SERVICES STEPS

1. Probably the most common problem is a faulty spark plug; however, this should not be a conclusion without proper examination.
2. Check out the ignition system with a scope and associated instruments. If the scope does not clearly show a faulty spark plug, observe for the following:
   a. Faulty ignition cables.
   b. Point arcing.
   c. Cross fire, due to cracked or carbon tracked cap or rotor.
   d. If above steps do not locate the source of trouble, refer to "Ignition Check Sheet," page 18, for added assistance.

ALWAYS MAKE THE BASIC ADJUSTMENTS OF IGNITION DWELL AND TIMING, IDLE SPEED AND AIR FUEL RATIO, TO COMPLETE THE REPAIR.

CHART #6

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC	✓		✓

ABNORMALLY HIGH HC AT IDLE AND HIGH CRUISE

	IDLE	LOW CRUISE	HIGH CRUISE
CO			
HC	✓	✓	✓

ABNORMALLY HIGH HC IN ALL MODES OF OPERATION

USUAL CAUSES

The most probable cause is ignition misfire as described on Chart #5.

SERVICE STEPS

1. Refer to Chart #5 and repair accordingly.

2. In RARE cases, it may be necessary to refer also to Chart #4 when repair, as prescribed by Chart #5, does not bring Idle Hydrocarbons within a reasonable limit.

ALWAYS MAKE THE BASIC IDLE ADJUSTMENTS OF IGNITION DWELL AND TIMING, IDLE SPEED AND AIR FUEL RATIO, TO COMPLETE THE REPAIR.

CARBON MONOXIDE AND HYDROCARBON

Combinations of CO and HC Problems

Rejects in upper and lower boxes are simply combinations of problems causing abnormally high CO and those causing abnormally high HC. They are to be treated as separate and independent problems.

Repairs will be based on a combination of a CO chart which matches the checks in the upper row of boxes, and a HC chart which matches the checks in the lower row of boxes.

> NOTE: As a quick reference, a master wall chart has been included on the following page. This will be an aid in quickly finding the proper Truth Chart(s) and page number(s) for given reject situations.

CARBURETOR CHECK SHEET

NOTE: In rebuilding a carburetor, the following defects must be looked for. If one or more of these defects is not observed or cannot be corrected, it is suggested that the carburetor be discarded and replaced according to manufacturers recommendations.

1. Check for faulty power enrichening valve.
2. Check to be sure that all vacuum passages controlling the power enrichening valve are open and unobstructed.
3. Observe for loose main jet(s) and/or power enrichening valve.
4. Check for pitted or cracked main jet seat of seat gasket.
5. Check for worn jets and/or metering rods. A slight amount of wear can cause a grossly higher CO reading.
6. Examine the float for abnormal damage or leaks.
7. Check for a damaged or loose float valve.
8. Check the venturi cluster and cluster gasket for damage or cracks.
9. Thoroughly inspect the entire body of the carburetor for cracks and to see that all lead plugs are securely in place.

IGNITION CHECK SHEET

NOTE: Below are guidelines as to problems to look for that can cause ignition misfires and high hydrocarbons. In most cases, the problem can be traced to one of these areas and should be done so by proper diagnosis, not by repairing and replacing until the problem has been corrected.

This list is prepared in order with the most commonly occurring problems listed at the top, and the least common toward the bottom.

1. Spark plugs.
2. Spark plug cables and coil cable resistance.
3. Excessive point resistance or arcing.
4. Distributor cap and rotor cracks and carbon tracks.
5. Moisture inside the distributor cap or on the cables.
6. Extremely incorrect dwell angle or point gap.
7. Low coil output voltage.
8. Low primary voltage supplied to the coil.
9. Loose wire connections such as distributor plate ground or coil to point wire connections.

APPENDIX B

1975 CVS EMISSION DATA

B-1: Phase I Data

B-2: Phase II Data

CAL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	11.	8.4	7.7	3.2	30.1	97.7	71.8	29.3	217.4	1.5	0.9	0.4	3.2
62-5	22.	5.7	1.8	3.0	10.4	64.8	33.0	13.0	135.4	2.9	1.6	0.6	6.5
66-7	14.	9.3	9.5	1.5	30.9	75.8	37.9	15.8	134.7	2.4	1.6	0.7	6.5
68-9	16.	3.8	2.5	1.2	12.2	52.1	30.9	13.1	120.9	2.9	1.3	1.0	6.0
70-1	12.	2.8	1.4	0.9	5.5	42.2	32.8	9.5	108.0	2.7	1.5	1.0	6.4
CUM	75.	5.9	5.7	0.9	30.9	65.3	43.7	9.5	217.4	2.6	1.5	0.4	6.5

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	1.	4.4	0.0	4.4	4.4	30.5	0.0	30.5	30.5	1.8	0.0	1.8	1.8
X2	7.	4.9	1.7	2.6	6.8	63.0	32.1	26.6	108.0	2.8	1.2	1.5	4.4
X3	12.	2.9	1.3	0.9	5.0	39.4	25.7	9.5	88.3	3.6	1.6	1.6	6.4
X4	8.	4.0	3.5	1.2	12.2	50.0	25.5	13.1	95.2	2.3	0.8	1.0	3.6
X5	8.	7.7	9.6	1.5	30.9	76.2	68.0	15.8	217.4	2.0	1.6	0.5	5.1
X6	11.	4.0	1.5	1.6	6.1	59.2	38.1	17.1	122.0	2.8	1.4	0.9	5.5
X7	5.	5.8	1.8	3.8	8.4	72.6	31.0	41.5	118.4	2.5	2.3	0.7	6.5
X8	7.	6.0	2.5	3.2	10.4	65.9	22.5	38.3	96.7	1.8	1.3	0.6	4.0
X9	6.	6.0	3.1	3.4	12.0	64.7	42.8	13.0	134.7	2.1	0.8	0.8	3.2
X10	5.	9.2	3.5	4.5	13.4	113.2	70.4	41.1	211.9	3.1	2.2	0.6	6.5
X11	3.	15.0	12.7	5.7	29.5	121.2	51.5	84.6	180.1	1.8	1.2	0.4	2.6
X12	2.	16.7	19.0	3.2	30.1	76.2	39.3	48.5	104.0	2.3	0.3	2.1	2.5
CUM	75.	5.9	5.7	0.9	30.9	65.3	43.7	9.5	217.4	2.6	1.5	0.4	6.5

CAL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	3.	4.1	2.2	1.6	5.5	39.3	37.7	17.1	82.7	3.2	2.0	1.8	5.5
CHRY	1.	4.5	0.0	4.5	4.5	41.1	0.0	41.1	41.1	3.4	0.0	3.4	3.4
DODG	4.	3.8	0.3	3.6	4.1	30.4	7.4	23.3	37.3	3.3	1.0	2.0	4.3
PLYM	4.	9.0	4.4	4.4	13.4	52.2	18.3	30.5	75.0	3.4	2.1	1.8	6.5
FORD	15.	4.7	1.7	1.6	7.9	71.4	46.9	12.4	217.4	3.2	2.1	0.5	6.5
MERC	3.	3.3	1.5	1.7	4.7	31.5	19.7	13.0	52.1	2.5	0.8	1.6	3.2
BUIC	4.	7.6	3.6	4.3	11.7	140.9	50.2	95.2	211.9	1.7	0.9	0.6	2.7
CADI	2.	4.4	2.4	2.7	6.1	91.0	43.9	60.0	122.0	2.4	1.7	1.2	3.6
CHEV	16.	6.5	6.5	2.2	29.5	67.0	39.5	26.6	180.1	2.5	1.0	0.4	4.4
OLDS	4.	10.7	13.1	1.5	30.1	67.8	38.5	15.8	104.0	2.8	1.1	1.7	4.4
PONT	5.	4.5	1.9	2.6	7.2	71.8	40.1	39.8	128.9	3.1	1.0	2.0	4.3
IMPT	5.	3.5	3.0	1.2	8.4	51.2	44.6	9.9	118.4	1.5	0.6	0.7	2.3
VW	9.	7.5	9.6	0.9	30.9	60.2	45.2	9.5	134.7	1.2	0.7	0.6	2.5
CUM	75.	5.9	5.7	0.9	30.9	65.3	43.7	9.5	217.4	2.6	1.5	0.4	6.5

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	2.	3.0	2.0	1.6	4.4	23.8	9.5	17.1	30.5	2.1	0.4	1.8	2.4
C.D.	38.	7.4	6.0	2.8	30.9	78.6	49.0	13.0	217.4	2.4	1.6	0.4	6.5
A.I.	10.	5.2	8.6	1.2	29.5	48.2	29.8	9.9	96.7	2.4	0.9	1.1	3.9
E.M.	25.	4.1	2.7	0.9	12.2	55.4	34.8	9.5	134.7	3.0	1.4	0.8	6.4
CUM	75.	5.9	5.7	0.9	30.9	65.3	43.7	9.5	217.4	2.6	1.5	0.4	6.5

```
             CAL IDLE BEFORE SERVICE          1975 CVS TEST            - PHASE 1 DATA

                                  ALL CARS

                                100"  CLASS
 CID  NO.          HYDROCARBON                   CARBON MONOXIDE              NITROGEN OXIDES
100" CARS    MEAN   SDEV    MIN    MAX     MEAN   SDEV    MIN    MAX      MEAN   SDEV    MIN    MAX
  X1   15.    5.8    7.8    0.9   30.9     54.0   43.5    9.5  134.7       1.4    0.8    0.6    3.0
  X2    7.    4.7    1.6    3.2    7.9     60.3   70.9   13.0  217.4       2.4    1.6    0.5    5.5
  X3   17.    5.0    2.1    1.6    9.8     63.3   39.0   17.1  180.1       2.7    1.5    0.4    6.5
  X4   27.    7.0    7.1    1.5   30.1     63.6   29.8   15.8  128.9       3.2    1.4    0.9    6.5
  X5    9.    5.4    3.2    1.7   11.7     97.2   57.1   36.1  211.9       2.6    1.7    0.6    6.4
 CUM   75.    5.9    5.7    0.9   30.9     65.3   43.7    9.5  217.4       2.6    1.5    0.4    6.5

                                 1K#  CLASS
 *T   NO.          HYDROCARBON                   CARBON MONOXIDE              NITROGEN OXIDES
 1K* CARS    MEAN   SDEV    MIN    MAX     MEAN   SDEV    MIN    MAX      MEAN   SDEV    MIN    MAX
  X2    0.    0.0    0.0 9999.0-9999.0      0.0    0.0 9999.0-9999.0       0.0    0.0 9999.0-9999.0
  X3   18.    5.9    7.0    0.9   30.9     62.3   55.2    9.5  217.4       1.6    1.2    0.5    5.5
  X4   24.    4.2    2.0    1.2    9.8     52.3   38.4   13.0  180.1       2.6    1.3    0.4    6.5
  X5   30.    7.4    6.7    1.7   30.1     76.3   39.2   24.8  211.9       3.0    1.5    0.6    6.5
  X6    3.    4.7    1.8    2.7    6.1     77.5   38.8   50.6  122.0       3.3    2.0    1.2    5.1
 CUM   75.    5.9    5.7    0.9   30.9     65.3   43.7    9.5  217.4       2.6    1.5    0.4    6.5
```

CAL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	11.	8.3	7.7	3.2	30.1	85.6	55.8	29.3	211.9	1.5	0.9	0.4	3.2
62-5	22.	5.3	1.7	3.0	10.4	54.6	21.7	13.0	98.8	2.7	1.4	0.6	5.9
66-7	14.	5.3	3.5	1.5	13.4	54.8	27.7	8.4	101.5	2.8	1.7	0.5	6.5
68-9	16.	3.7	2.5	1.2	12.2	49.8	30.4	13.1	120.9	2.7	1.0	1.0	4.4
70-1	12.	2.7	1.3	0.9	5.5	37.8	28.2	9.5	108.0	2.7	1.5	1.5	6.4
CUM	75.	5.0	3.9	0.9	30.1	55.5	34.5	8.4	211.9	2.6	1.4	0.4	6.5

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	1.	4.4	0.0	4.4	4.4	30.5	0.0	30.5	30.5	1.8	0.0	1.8	1.8
X2	7.	4.9	1.7	2.6	6.8	63.0	32.1	26.6	108.0	2.8	1.2	1.5	4.4
X3	12.	2.7	1.1	0.9	4.3	36.4	23.0	9.5	88.3	3.2	1.4	1.6	6.4
X4	8.	3.8	3.5	1.2	12.2	43.5	17.8	13.1	67.6	2.3	0.7	1.6	3.6
X5	8.	5.1	3.3	1.5	12.0	53.7	37.2	15.8	132.6	2.2	1.6	0.4	5.1
X6	11.	3.8	1.3	1.6	6.2	54.5	32.7	17.1	120.9	2.8	1.5	1.2	6.3
X7	5.	4.7	1.1	3.8	6.6	48.9	29.1	8.4	89.4	2.4	1.2	1.2	4.3
X8	7.	5.8	2.4	3.2	10.4	68.0	19.9	45.2	96.7	1.7	0.9	0.6	3.1
X9	6.	4.9	1.0	3.4	5.7	43.9	25.4	13.0	82.7	2.7	1.8	0.5	5.9
X10	5.	8.8	3.7	4.5	13.4	89.7	70.3	41.1	211.9	3.0	2.2	0.6	6.5
X11	3.	6.1	3.3	2.9	9.5	96.6	36.3	59.2	131.7	1.6	1.0	0.6	2.6
X12	2.	16.7	19.0	3.2	30.1	76.2	39.3	48.5	104.0	2.3	0.3	2.1	2.5
CUM	75.	5.0	3.9	0.9	30.1	55.5	34.5	8.4	211.9	2.6	1.4	0.4	6.5

CAL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
AMC	3.	3.8	2.0	1.6	5.5	40.3	36.8	17.1	82.7	1.8	0.6	1.2	2.4
CHRY	1.	4.5	0.0	4.5	4.5	41.1	0.0	41.1	41.1	3.4	0.0	3.4	3.4
DODG	4.	3.8	0.3	3.6	4.1	30.4	7.4	23.3	37.3	3.3	1.0	2.0	4.3
PLYM	4.	8.9	4.5	4.4	13.4	39.5	14.6	24.1	54.8	4.3	2.3	1.8	6.5
FORD	15.	4.3	1.5	1.6	7.5	60.4	29.7	12.4	132.6	3.1	1.9	0.4	6.4
MERC	3.	3.3	1.5	1.7	4.7	31.5	19.7	13.0	52.1	2.5	0.8	1.6	3.2
BUIC	4.	6.7	3.5	4.2	11.7	121.2	64.5	67.6	211.9	1.4	0.5	0.6	1.8
CADI	2.	4.4	2.5	2.7	6.2	80.7	29.4	60.0	101.5	2.9	1.0	2.2	3.6
CHEV	16.	4.7	2.0	2.2	9.5	61.0	27.8	26.6	131.7	2.4	0.9	0.6	4.4
OLDS	4.	10.7	13.1	1.5	30.1	67.8	38.5	15.8	104.0	2.8	1.1	1.7	4.4
PONT	5.	4.6	2.1	2.6	7.8	58.6	24.4	39.8	99.4	3.3	0.9	2.0	4.3
IMPT	5.	2.5	1.4	1.2	4.0	24.3	19.0	8.4	46.8	1.9	0.4	1.6	2.5
VW	9.	4.8	3.9	0.9	12.0	45.5	27.6	9.5	94.6	1.5	0.9	0.5	2.9
CUM	75.	5.0	3.9	0.9	30.1	55.5	34.5	8.4	211.9	2.6	1.4	0.4	6.5

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
N.C.	2.	3.0	2.0	1.6	4.4	23.8	9.5	17.1	30.5	2.1	0.4	1.8	2.4
C.O.	38.	6.5	4.7	2.8	30.1	64.3	38.2	8.4	211.9	2.4	1.4	0.4	6.5
A.I.	10.	2.5	1.2	1.2	4.6	44.7	26.9	9.9	96.7	2.6	1.5	1.1	6.3
E.M.	25.	3.8	2.1	0.9	12.2	48.9	29.0	9.5	120.9	2.8	1.3	0.5	6.4
CUM	75.	5.0	3.9	0.9	30.1	55.5	34.5	8.4	211.9	2.6	1.4	0.4	6.5

```
                   CAL IDLE SECOND SERVICE          1975 CVS TEST                 - PHASE 1 DATA

                                             ALL CARS

                                            100"  CLASS
 CID   NO.               HYDROCARBON                     CARBON MONOXIDE                   NITROGEN OXIDES
100"  CARS      MEAN    SDEV    MIN     MAX      MEAN    SDEV    MIN     MAX       MEAN    SDEV    MIN     MAX
 X1    15.       3.8     3.3    0.9    12.0      36.2    26.2    8.4    94.6        1.7     0.8    0.5     3.0
 X2     7.       4.5     1.4    3.2     7.5      48.7    39.9   13.0   132.6        1.8     0.9    0.4     3.2
 X3    17.       4.8     2.0    1.6     9.5      58.0    28.2   17.1   131.7        2.7     1.4    0.6     6.3
 X4    27.       5.9     5.5    1.5    30.1      56.1    26.0   15.8   108.0        3.2     1.3    1.5     6.5
 X5     9.       5.0     3.0    1.7    11.7      86.2    54.8   36.1   211.9        2.5     1.7    0.6     6.4
 CUM   75.       5.0     3.9    0.9    30.1      55.5    34.5    8.4   211.9        2.6     1.4    0.4     6.5

                                            1K#  CLASS
 WT    NO.               HYDROCARBON                     CARBON MONOXIDE                   NITROGEN OXIDES
 1K#  CARS      MEAN    SDEV    MIN     MAX      MEAN    SDEV    MIN     MAX       MEAN    SDEV    MIN     MAX
 X2     0.       0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0
 X3    18.       4.2     3.0    0.9    12.0      43.0    32.5    8.4   132.6        1.6     0.8    0.4     3.0
 X4    24.       4.0     1.9    1.2     9.5      47.8    29.9   13.0   131.7        2.7     1.3    0.6     6.3
 X5    30.       6.3     5.3    1.7    30.1      67.6    36.5   24.1   211.9        3.0     1.5    0.6     6.5
 X6     3.       4.7     1.8    2.7     6.2      70.7    27.1   50.6   101.5        3.6     1.4    2.2     5.1
 CUM   75.       5.0     3.9    0.9    30.1      55.5    34.5    8.4   211.9        2.6     1.4    0.4     6.5
```

CAL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
57-1	12.	7.9	5.3	3.1	19.9	66.8	31.3	28.0	125.0	2.5	1.3	0.2	4.0
62-5	20.	7.4	4.5	1.9	21.4	103.6	56.5	22.4	232.5	2.0	1.1	0.3	4.7
66-7	14.	8.6	8.0	2.1	28.3	70.1	32.5	25.1	137.4	2.6	1.3	0.3	4.6
68-9	17.	4.1	1.8	1.3	8.2	62.1	35.7	17.4	147.4	3.0	1.8	0.9	6.5
70-1	12.	3.0	0.9	1.7	4.3	41.8	28.5	7.1	96.2	3.1	1.6	0.8	6.1
CUM	75.	6.3	5.1	1.3	28.3	72.2	44.6	7.1	232.5	2.6	1.4	0.2	6.5

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	1.	2.9	0.0	2.9	2.9	18.2	0.0	18.2	18.2	1.9	0.0	1.9	1.9
X2	6.	4.0	2.6	1.7	8.9	44.7	35.5	18.6	112.3	2.2	1.3	1.1	4.6
X3	8.	2.7	0.6	1.7	3.6	34.1	16.6	7.1	62.7	3.6	1.7	1.5	6.5
X4	4.	4.2	2.1	1.3	6.4	67.6	44.1	20.4	118.8	2.3	2.1	0.8	5.3
X5	7.	5.3	0.7	4.3	6.4	84.1	29.3	58.0	143.6	3.4	1.5	2.0	5.5
X6	16.	5.8	3.5	1.7	14.9	77.2	40.3	17.4	147.4	2.0	1.5	0.2	5.3
X7	8.	9.1	7.5	3.0	21.4	78.9	29.2	49.9	125.0	2.7	1.0	1.1	4.6
X8	10.	8.0	7.4	3.1	28.3	75.3	34.0	25.1	150.2	3.0	1.3	0.4	4.6
X9	7.	8.9	4.9	3.3	15.6	102.1	85.5	22.4	232.5	2.3	1.3	0.3	4.0
X10	5.	9.5	8.1	4.2	23.8	99.3	47.6	54.8	171.9	2.1	1.0	1.0	3.6
X11	1.	7.7	0.0	7.7	7.7	96.0	0.0	96.0	96.0	2.5	0.0	2.5	2.5
X12	2.	2.5	0.9	1.9	3.1	32.8	6.8	28.0	37.7	2.9	1.3	2.0	3.8
CUM	75.	6.3	5.1	1.3	28.3	72.2	44.6	7.1	232.5	2.6	1.4	0.2	6.5

CAL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	3.	4.7	2.7	1.7	7.0	72.7	44.7	33.8	121.6	1.7	1.0	1.0	2.8
CHRY	1.	7.9	0.0	7.9	7.9	171.9	0.0	171.9	171.9	1.5	0.0	1.5	1.5
DODG	4.	3.7	1.6	2.7	6.0	51.2	24.5	30.8	85.8	3.7	1.2	2.4	5.3
PLYM	4.	3.5	0.9	2.3	4.3	41.8	16.7	17.4	54.8	3.1	0.8	2.4	4.0
FORD	15.	5.9	4.3	2.3	19.9	68.2	31.5	25.4	137.4	3.1	1.4	0.6	5.5
MERC	3.	9.7	12.3	1.9	23.8	53.6	21.8	37.7	78.5	2.6	1.2	2.0	4.0
BUIC	5.	6.5	2.8	4.3	10.8	120.5	26.6	87.6	147.4	1.6	0.6	0.8	2.4
CADI	2.	17.4	15.5	6.4	28.3	89.8	41.1	60.7	118.8	3.3	1.8	2.1	4.6
CHEV	15.	8.1	5.5	2.5	21.4	90.4	52.8	18.2	232.5	2.5	1.7	0.2	6.5
OLDS	4.	5.3	2.5	2.1	8.2	49.9	31.3	22.4	90.7	2.2	0.6	1.5	2.9
PONT	5.	6.0	2.6	3.6	10.3	105.2	62.5	55.9	213.9	2.7	1.4	1.3	4.6
IMPT	5.	3.0	1.7	1.3	4.9	23.5	13.2	7.1	43.7	3.5	2.1	0.9	6.1
VW	9.	5.1	4.0	1.7	14.9	53.8	29.6	18.6	111.8	1.5	0.8	0.3	2.8
CUM	75.	6.3	5.1	1.3	28.3	72.2	44.6	7.1	232.5	2.6	1.4	0.2	6.5

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	3.	8.9	9.5	2.6	19.9	48.8	13.7	33.1	58.5	2.9	1.2	1.5	3.6
C.D.	34.	8.0	5.6	1.9	28.3	88.1	51.5	22.4	232.5	2.2	1.2	0.2	4.7
A.I.	12.	5.6	6.1	1.3	23.8	61.9	41.3	7.1	137.4	2.6	1.5	0.6	6.1
E.M.	26.	4.0	1.5	1.7	8.2	58.7	31.4	17.4	147.4	3.1	1.6	0.8	6.5
CUM	75.	6.3	5.1	1.3	28.3	72.2	44.6	7.1	232.5	2.6	1.4	0.2	6.5

```
                 CAL K.M. BEFORE SERVICE          1975 CVS TEST              - PHASE 1 DATA

                                   ALL CARS

                                       100"  CLASS
 CID  NO.              HYDROCARBON                     CARBON MONOXIDE                      NITROGEN OXIDES
100" CARS      MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
 X1   15.       4.3     3.3     1.3    14.9      41.9    27.9     7.1   111.8       2.4     1.7     0.3     6.1
 X2    7.       5.6     4.7     1.9    15.6      69.4    45.8    28.0   143.6       2.5     1.2     1.0     4.0
 X3   17.       7.1     4.9     1.7    21.4      92.3    48.8    33.1   232.5       2.1     1.3     0.2     4.2
 X4   25.       5.6     3.7     2.1    19.9      64.9    40.2    17.4   213.9       3.1     1.3     1.2     6.5
 X5   11.       9.6     8.5     2.3    28.3     100.6    40.2    25.4   171.9       2.6     1.5     0.8     5.5
CUM   75.       6.3     5.1     1.3    28.3      72.2    44.6     7.1   232.5       2.6     1.4     0.2     6.5

                                       1K#  CLASS
 WT   NO.              HYDROCARBON                     CARBON MONOXIDE                      NITROGEN OXIDES
 1K# CARS      MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
 X2    0.       0.0     0.0 9999.0-9999.0         0.0     0.0 9999.0-9999.0         0.0     0.0 9999.0-9999.0
 X3   16.       5.1     4.2     1.7    15.6      45.7    27.4     7.1   111.8       2.6     1.6     0.3     6.1
 X4   29.       4.7     2.8     1.3    15.0      69.8    47.9    18.2   232.5       2.5     1.4     0.3     6.5
 X5   27.       7.8     5.6     2.3    23.8      88.1    44.3    17.4   213.9       2.6     1.3     0.2     5.5
 X6    3.      14.2    12.3     6.4    28.3      92.4    29.4    60.7   118.8       3.8     1.5     2.1     4.7
CUM   75.       6.3     5.1     1.3    28.3      72.2    44.6     7.1   232.5       2.6     1.4     0.2     6.5
```

CAL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	12.	6.2	3.4	3.1	14.5	68.5	43.5	28.0	182.5	2.6	1.5	0.5	5.9
62-5	20.	5.7	2.0	1.9	8.8	82.5	41.9	22.4	171.9	2.1	1.1	0.4	4.7
66-7	14.	6.1	6.6	2.1	28.3	60.6	29.1	25.1	137.4	2.5	1.3	0.6	4.6
68-9	17.	3.7	1.7	1.3	8.2	59.7	41.7	17.4	147.4	2.8	1.7	0.6	6.5
70-1	12.	3.0	0.9	1.7	4.3	39.9	29.0	7.1	96.2	3.2	1.6	0.8	6.1
CUM	75.	5.0	3.6	1.3	28.3	64.2	39.7	7.1	182.5	2.6	1.5	0.4	6.5

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	1.	2.9	0.0	2.9	2.9	18.2	0.0	18.2	18.2	1.9	0.0	1.9	1.9
X2	6.	3.5	1.7	1.7	6.4	39.0	21.5	18.6	74.6	2.0	1.3	0.9	4.6
X3	8.	2.7	0.6	1.7	3.6	31.4	16.4	7.1	62.7	3.7	1.7	1.5	6.5
X4	4.	4.2	2.1	1.3	6.4	67.6	44.1	20.4	118.8	2.3	2.1	0.8	5.3
X5	7.	4.9	1.0	3.0	5.9	76.8	37.2	24.0	143.6	3.2	1.6	2.0	5.5
X6	16.	5.3	3.3	1.7	14.5	74.3	47.3	17.4	182.5	2.2	1.4	0.5	5.3
X7	8.	5.2	2.8	2.1	10.8	72.8	40.6	34.7	145.3	2.6	1.5	0.6	5.9
X8	10.	7.2	7.6	3.1	28.3	65.5	24.5	25.1	107.1	3.0	1.3	0.6	4.6
X9	7.	5.6	1.7	3.3	7.9	69.9	45.5	22.4	159.2	1.9	1.2	0.4	4.0
X10	5.	5.2	2.3	2.1	7.9	93.4	52.3	49.4	171.9	1.9	1.1	1.0	3.6
X11	1.	5.9	0.0	5.9	5.9	55.5	0.0	55.5	55.5	3.2	0.0	3.2	3.2
X12	2.	2.5	0.9	1.9	3.1	32.8	6.8	28.0	37.7	2.9	1.3	2.0	3.8
CUM	75.	5.0	3.6	1.3	28.3	64.2	39.7	7.1	182.5	2.6	1.5	0.4	6.5

CAL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	3.	4.7	2.7	1.7	7.0	72.7	44.7	33.8	121.6	1.7	1.0	1.0	2.8
CHRY	1.	7.9	0.0	7.9	7.9	171.9	0.0	171.9	171.9	1.5	0.0	1.5	1.5
DODG	4.	3.7	1.6	2.7	6.0	51.2	24.5	30.8	85.8	3.7	1.2	2.4	5.3
PLYM	4.	3.5	0.9	2.3	4.3	41.8	16.7	17.4	54.8	3.1	0.8	2.4	4.0
FORD	15.	4.9	1.8	2.3	7.8	63.9	31.0	25.4	137.4	3.3	1.6	0.6	5.9
MERC	3.	2.4	0.8	1.9	3.3	43.9	5.9	37.7	49.4	2.3	1.5	1.1	4.0
BUIC	5.	6.5	2.3	4.3	10.8	120.5	26.6	87.6	147.4	1.6	0.6	0.8	2.4
CADI	2.	17.4	15.5	6.4	28.3	89.8	41.1	60.7	118.8	3.3	1.8	2.1	4.6
CHEV	15.	5.5	3.1	2.5	14.5	71.0	47.0	18.2	182.5	2.5	1.6	0.4	6.5
OLDS	4.	5.3	2.5	2.1	8.2	49.9	31.3	22.4	90.7	2.2	0.6	1.5	2.9
PONT	5.	4.6	1.1	3.3	5.9	88.7	33.6	55.9	145.3	2.1	1.1	1.3	3.9
IMPT	5.	3.0	1.7	1.3	4.9	23.5	13.2	7.1	43.7	3.5	2.1	0.9	6.1
VW	9.	3.5	1.3	1.7	5.4	39.4	15.0	18.6	58.7	1.5	0.9	0.6	3.4
CUM	75.	5.0	3.6	1.3	28.3	64.2	39.7	7.1	182.5	2.6	1.5	0.4	6.5

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	3.	4.9	2.7	2.6	7.8	49.2	14.2	33.1	59.8	3.6	2.2	1.5	5.9
C.D.	34.	6.4	4.6	1.9	28.3	74.9	42.4	22.4	182.5	2.2	1.2	0.4	4.7
A.I.	12.	3.6	1.9	1.3	6.7	54.9	39.5	7.1	137.4	2.5	1.5	0.6	6.1
E.M.	26.	3.7	1.5	1.7	8.2	56.3	36.2	17.4	147.4	2.9	1.6	0.6	6.5
CUM	75.	5.0	3.6	1.3	28.3	64.2	39.7	7.1	182.5	2.6	1.5	0.4	6.5

```
               CAL K.M. SECOND SERVICE          1975 CVS TEST                  - PHASE 1 DATA

                                       ALL CARS

                                          100"  CLASS
 CID   NO.            HYDROCARBON                    CARBON MONOXIDE                     NITROGEN OXIDES
100"  CARS    MEAN    SDEV     MIN     MAX     MEAN     SDEV     MIN     MAX       MEAN     SDEV     MIN     MAX
 X1    15.     3.3     1.4     1.3     5.4     33.2     15.5     7.1    58.7        2.4      1.7     0.6     6.1
 X2     7.     4.1     1.6     1.9     7.0     66.5     46.2    28.0   143.6        2.3      1.2     1.0     4.0
 X3    17.     5.4     2.9     1.7    14.5     79.1     43.7    33.1   182.5        2.2      1.2     0.4     4.2
 X4    25.     4.7     2.0     2.1     8.8     55.2     23.7    17.4    97.6        3.1      1.4     1.3     6.5
 X5    11.     7.5     7.4     2.1    28.3    102.4     45.0    25.4   171.9        2.3      1.5     0.8     5.5
 CUM   75.     5.0     3.6     1.3    28.3     64.2     39.7     7.1   182.5        2.6      1.5     0.4     6.5

                                          1K#  CLASS
 WT    NO.            HYDROCARBON                    CARBON MONOXIDE                     NITROGEN OXIDES
 1K#  CARS    MEAN    SDEV     MIN     MAX     MEAN     SDEV     MIN     MAX       MEAN     SDEV     MIN     MAX
 X2     0.     0.0     0.0 9999.0-9999.0        0.0      0.0 9999.0-9999.0          0.0      0.0 9999.0-9999.0
 X3    16.     3.5     1.3     1.7     5.4     36.3     15.8     7.1    58.7        2.4      1.6     0.6     6.1
 X4    29.     4.0     1.6     1.3     7.9     61.8     38.2    18.2   159.2        2.5      1.4     0.4     6.5
 X5    27.     5.8     2.8     2.1    14.5     80.2     43.2    17.4   182.5        2.6      1.4     0.5     5.9
 X6     3.    14.2    12.3     6.4    28.3     92.4     29.4    60.7   118.8        3.8      1.5     2.1     4.7
 CUM   75.     5.0     3.6     1.3    28.3     64.2     39.7     7.1   182.5        2.6      1.5     0.4     6.5
```

MI. IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

		HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	NO. CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	3.	10.7	8.0	6.0	20.0	84.5	9.2	78.8	95.1	4.9	3.6	2.2	8.9
62-5	19.	10.9	8.5	3.2	32.4	121.6	81.8	56.0	375.0	2.7	1.5	0.5	5.2
66-7	16.	6.1	2.3	2.7	11.2	83.4	27.7	17.9	132.8	3.1	1.4	0.9	5.9
68-9	21.	4.5	2.0	0.9	9.4	70.3	40.0	19.8	176.9	4.7	1.8	1.0	6.8
70-1	15.	4.4	1.8	1.6	7.8	58.8	41.0	7.9	144.0	5.3	2.0	1.5	7.9
CUM	74.	6.7	5.5	0.9	32.4	84.6	55.9	7.9	375.0	4.0	2.0	0.5	8.9

10K CLASS

		HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MILE 10K	NO. CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	6.	2.8	0.9	1.6	4.2	29.2	12.3	7.9	39.8	6.5	0.7	5.4	7.5
X2	8.	6.8	5.5	2.7	20.0	77.1	34.6	27.2	120.5	4.5	1.9	2.2	7.1
X3	6.	5.2	1.1	4.0	6.8	79.6	53.9	24.5	176.9	4.8	2.4	1.7	7.9
X4	12.	5.0	2.5	0.9	9.4	84.6	40.1	19.8	144.0	3.7	2.0	1.0	6.8
X5	14.	5.8	2.8	2.7	11.2	79.6	19.4	38.1	105.0	3.6	1.4	0.9	5.5
X6	10.	6.6	3.7	3.3	16.0	87.7	77.3	26.8	299.8	3.7	1.9	0.5	6.7
X7	6.	6.4	3.2	2.4	10.3	117.3	130.7	17.9	375.0	3.4	2.3	1.7	6.6
X8	4.	6.9	4.0	3.2	12.6	104.4	43.7	56.0	142.6	3.9	3.5	1.1	8.9
X9	5.	16.5	12.2	6.1	32.4	107.8	35.4	58.4	149.9	2.4	1.9	0.8	5.2
X10	2.	6.5	0.5	6.1	6.8	114.7	6.8	109.9	119.5	3.3	1.7	2.1	4.4
X11	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X12	1.	25.7	0.0	25.7	25.7	90.1	0.0	90.1	90.1	4.3	0.0	4.3	4.3
CUM	74.	6.7	5.5	0.9	32.4	84.6	55.9	7.9	375.0	4.0	2.0	0.5	8.9

MI. IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	2.	3.1	0.6	2.7	3.6	46.7	12.1	38.1	55.3	3.6	1.1	2.8	4.3
CHRY	2.	6.3	4.4	3.2	9.4	80.5	34.7	56.0	105.0	3.5	3.5	1.1	6.0
DODG	4.	5.8	4.5	1.6	10.9	39.0	38.6	7.9	94.2	6.3	1.0	5.1	7.5
PLYM	5.	3.8	1.8	1.7	5.7	69.1	49.8	19.8	142.6	4.7	1.7	2.2	6.8
FORD	16.	6.2	3.2	2.7	16.0	101.3	65.5	24.0	299.8	3.6	2.4	0.5	8.9
MERC	3.	4.9	1.1	4.0	6.2	66.6	26.1	39.9	92.0	5.9	1.6	4.1	7.1
BUIC	6.	9.5	11.3	3.1	32.4	103.7	39.3	39.8	149.9	3.5	2.3	0.8	6.6
CADI	2.	6.2	2.5	4.4	8.0	98.5	29.6	77.6	119.5	6.2	2.5	4.4	7.9
CHEV	17.	9.3	7.6	2.7	27.0	78.7	29.2	24.5	140.2	4.0	1.4	1.8	6.6
OLDS	6.	5.6	2.7	3.3	10.3	123.8	125.7	39.6	375.0	3.7	1.9	1.7	6.0
PONT	7.	6.2	2.0	3.1	8.7	81.0	33.5	26.8	132.8	3.6	2.0	0.9	6.7
IMPT	1.	3.2	0.0	3.2	3.2	59.9	0.0	59.9	59.9	1.0	0.0	1.0	1.0
VW	3.	4.9	5.5	0.9	11.2	51.1	46.8	21.2	105.0	1.9	0.9	0.9	2.5
CUM	74.	6.7	5.5	0.9	32.4	84.6	55.9	7.9	375.0	4.0	2.0	0.5	8.9

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	7.	13.0	10.4	4.3	32.4	124.2	81.8	69.5	299.8	3.2	2.9	0.5	8.9
C.D.	31.	7.8	5.6	2.7	27.0	97.9	58.0	24.0	375.0	3.0	1.4	0.9	6.3
A.I.	2.	5.6	2.2	4.0	7.2	63.9	5.0	60.3	67.4	5.2	0.1	5.2	5.3
E.M.	34.	4.5	2.0	0.9	9.4	65.4	41.7	7.9	176.9	4.9	1.9	1.0	7.9
CUM	74.	6.7	5.5	0.9	32.4	84.6	55.9	7.9	375.0	4.0	2.0	0.5	8.9

```
                  MI. IDLE BEFORE SERVICE           1975 CVS TEST                - PHASE 1 DATA

                                         ALL CARS

                                        100"  CLASS
 CID  NO.              HYDROCARBON                    CARBON MONOXIDE                   NITROGEN OXIDES
100" CARS      MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX
  X1   4.       4.5     4.6     0.9    11.2     53.3    38.4    21.2   105.0      1.7     0.8     0.9     2.5
  X2   6.       6.8     4.8     2.9    16.0    105.7    96.7    37.4   299.8      4.0     3.1     0.5     8.9
  X3  17.       7.0     4.4     2.7    20.0     91.0    34.0    24.0   144.0      3.3     1.3     1.5     6.3
  X4  37.       6.4     5.3     1.6    27.0     80.6    61.7     7.9   375.0      4.4     1.9     0.9     7.5
  X5  10.       8.2     8.6     4.0    32.4     88.2    38.4    26.8   149.9      4.6     2.5     0.8     7.9
 CUM  74.       6.7     5.5     0.9    32.4     84.6    55.9     7.9   375.0      4.0     2.0     0.5     8.9

                                        1K#  CLASS
 WT   NO.              HYDROCARBON                    CARBON MONOXIDE                   NITROGEN OXIDES
 1K# CARS      MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX
  X2   0.       0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0
  X3  12.       5.7     4.2     0.9    16.0     91.5    78.2    21.2   299.8      3.2     2.7     0.5     8.9
  X4  16.       5.4     2.2     2.4    10.9     70.7    25.7    24.5   105.9      4.0     1.6     1.7     6.6
  X5  43.       7.6     6.6     1.6    32.4     86.4    58.8     7.9   375.0      4.1     1.9     0.8     7.5
  X6   3.       6.0     1.8     4.4     8.0    104.0    23.0    77.6   119.5      5.7     2.0     4.4     7.9
 CUM  74.       6.7     5.5     0.9    32.4     84.6    55.9     7.9   375.0      4.0     2.0     0.5     8.9
```

MI. IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
57-1	3.	10.7	8.0	6.0	20.0	84.5	9.2	78.8	95.1	4.9	3.6	2.2	8.9
62-5	19.	6.9	5.0	2.7	25.7	84.1	27.6	14.0	140.1	2.9	1.4	0.9	5.5
66-7	16.	5.4	1.7	2.7	8.3	74.6	28.8	17.9	140.9	3.3	1.5	1.2	5.9
68-9	21.	3.5	1.4	0.9	6.8	54.6	39.9	17.3	176.9	4.7	1.8	1.0	7.0
70-1	15.	4.0	1.6	1.6	7.0	48.1	32.0	7.9	122.9	5.6	2.1	1.6	7.9
CUM	74.	5.2	3.5	0.9	25.7	66.4	34.8	7.9	176.9	4.1	2.0	0.9	8.9

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	6.	2.8	0.9	1.6	4.2	29.2	12.3	7.9	39.8	6.5	0.7	5.4	7.5
X2	8.	6.5	5.6	2.7	20.0	67.5	33.2	27.2	120.5	4.9	2.2	2.2	7.8
X3	6.	4.5	1.4	2.7	6.8	71.7	59.7	22.9	176.9	4.6	2.4	1.7	7.9
X4	12.	3.6	1.5	0.9	6.4	58.9	31.2	19.8	122.9	3.6	2.0	1.0	6.8
X5	14.	4.8	1.8	2.7	8.3	67.7	23.2	22.5	101.7	4.0	1.6	1.2	7.0
X6	10.	4.8	1.9	2.7	7.6	53.1	28.6	14.0	95.7	4.1	1.6	2.3	6.7
X7	6.	5.4	2.6	2.4	9.3	66.3	33.7	17.9	103.9	3.5	2.2	1.7	6.6
X8	4.	5.1	1.8	3.2	7.1	81.5	19.1	56.0	100.0	3.6	3.6	1.1	8.9
X9	5.	7.3	1.4	6.1	8.9	107.7	34.1	59.6	140.9	2.5	1.6	0.9	4.8
X10	2.	6.5	0.5	6.1	6.8	114.7	6.8	109.9	119.5	3.3	1.7	2.1	4.4
X11	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X12	1.	25.7	0.0	25.7	25.7	90.1	0.0	90.1	90.1	4.3	0.0	4.3	4.3
CUM	74.	5.2	3.5	0.9	25.7	66.4	34.8	7.9	176.9	4.1	2.0	0.9	8.9

MI. IDLE SECCND SERVICE   1975 CVS TEST   - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	2.	3.1	0.6	2.7	3.6	46.7	12.1	38.1	55.3	3.6	1.1	2.8	4.3
CHRY	2.	3.4	0.4	3.2	3.7	39.2	23.8	22.3	56.0	3.5	3.5	1.1	6.0
DODG	4.	4.1	2.8	1.6	8.0	33.8	28.9	7.9	73.6	6.2	1.3	4.5	7.5
PLYM	5.	3.5	1.5	1.7	5.3	58.8	33.5	19.8	91.1	4.3	2.1	2.1	6.8
FORD	16.	5.2	2.1	2.7	9.3	78.8	42.3	14.0	176.9	3.8	2.3	1.5	8.9
MERC	3.	4.0	0.4	3.6	4.5	48.2	17.3	36.6	68.0	6.4	0.7	5.7	7.1
BUIC	6.	5.2	2.2	3.0	8.9	93.9	35.5	39.8	140.1	3.6	2.2	1.5	6.6
CADI	2.	4.8	0.6	4.4	5.2	71.9	8.0	66.2	77.6	6.4	2.1	4.9	7.9
CHEV	17.	7.1	6.2	2.7	25.7	67.2	31.0	17.3	120.5	3.9	1.3	1.8	6.4
OLDS	6.	4.2	1.3	3.3	6.6	60.0	19.0	37.8	83.8	4.4	2.4	1.7	7.8
PONT	7.	5.9	1.8	2.9	8.7	73.4	42.2	22.5	140.9	4.2	2.3	0.9	7.0
IMPT	1.	3.2	0.0	3.2	3.2	59.9	0.0	59.9	59.9	1.0	0.0	1.0	1.0
VW	3.	3.5	3.0	0.9	6.8	40.8	28.9	21.2	74.0	2.0	0.7	1.2	2.5
CUM	74.	5.2	3.5	0.9	25.7	66.4	34.8	7.9	176.9	4.1	2.0	0.9	8.9

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	7.	7.8	5.7	2.7	20.0	81.9	37.8	14.0	140.1	4.0	2.6	1.5	8.9
C.D.	31.	6.1	4.1	2.7	25.7	79.9	24.4	24.0	140.9	3.0	1.4	0.9	6.3
A.I.	2.	2.8	0.2	2.7	2.9	22.8	7.7	17.3	28.2	4.9	0.7	4.4	5.4
E.M.	34.	3.9	1.7	0.9	8.0	53.4	37.0	7.9	176.9	5.1	2.0	1.0	7.9
CUM	74.	5.2	3.5	0.9	25.7	66.4	34.8	7.9	176.9	4.1	2.0	0.9	8.9

```
            MI. IDLE SECOND SERVICE          1975 CVS TEST           - PHASE 1 DATA

                                    ALL CARS

                                 100"  CLASS
 CID   NO.         HYDROCARBON                 CARBON MONOXIDE               NITROGEN OXIDES
100"  CARS    MEAN   SDEV    MIN     MAX    MEAN   SDEV    MIN     MAX     MEAN   SDEV    MIN     MAX
 X1     4.     3.4    2.4    0.9     6.8    45.5   25.5   21.2    74.0      1.7    0.7    1.0     2.5
 X2     6.     4.5    1.8    2.7     7.3    56.4   27.8   14.0    88.4      4.8    2.7    2.2     8.9
 X3    17.     6.1    4.1    2.7    20.0    79.9   28.4   24.0   122.9      3.2    1.4    1.6     6.3
 X4    37.     5.0    3.9    1.6    25.7    62.0   37.8    7.9   176.9      4.4    1.9    0.9     7.5
 X5    10.     5.3    1.6    3.5     8.9    74.1   35.8   26.8   140.1      5.1    2.5    1.5     7.9
 CUM   74.     5.2    3.5    0.9    25.7    66.4   34.8    7.9   176.9      4.1    2.0    0.9     8.9

                                 1K#  CLASS
 WT    NO.         HYDROCARBON                 CARBON MONOXIDE               NITROGEN OXIDES
 1K#  CARS    MEAN   SDEV    MIN     MAX    MEAN   SDEV    MIN     MAX     MEAN   SDEV    MIN     MAX
 X2     0.     0.0    0.0 9999.0-9999.0      0.0    0.0 9999.0-9999.0      0.0    0.0 9999.0-9999.0
 X3    12.     4.2    2.0    0.9     7.3    59.0   34.2   14.0   122.9      3.6    2.6    1.0     8.9
 X4    16.     4.4    1.7    2.4     9.3    59.7   28.7   22.5   105.9      4.1    1.8    1.7     7.0
 X5    43.     5.8    4.3    1.6    25.7    71.4   37.8    7.9   176.9      4.1    1.9    0.9     7.5
 X6     3.     4.4    0.9    3.5     5.2    60.5   20.5   37.8    77.6      6.9    1.7    4.9     7.9
 CUM   74.     5.2    3.5    0.9    25.7    66.4   34.8    7.9   176.9      4.1    2.0    0.9     8.9
```

MI. K.M. BEFORE SERVICE   1975 CVS TEST   - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	3.	4.5	1.5	3.3	6.3	53.2	3.9	50.1	57.7	2.4	1.2	1.3	3.7
62-5	20.	10.2	8.5	3.5	30.4	102.4	50.2	44.9	219.9	2.8	1.2	0.4	4.9
66-7	15.	8.1	3.6	2.1	14.0	107.2	55.9	30.3	258.2	3.6	1.7	1.0	7.4
68-9	21.	4.6	1.9	2.1	9.8	59.0	35.1	10.3	152.1	5.3	2.1	1.5	9.7
70-1	15.	3.7	1.2	1.7	6.6	47.6	28.8	7.6	93.3	5.4	1.1	2.8	6.9
CUM	74.	6.6	5.5	1.7	30.4	78.0	49.1	7.6	258.2	4.2	1.9	0.4	9.7

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	4.	2.7	1.3	1.7	4.4	25.0	22.6	7.6	58.1	6.0	0.7	5.1	6.9
X2	10.	4.0	1.2	2.4	6.6	50.5	24.3	30.4	93.3	4.7	1.7	1.5	6.9
X3	10.	4.0	1.8	2.1	8.4	54.3	29.7	10.3	107.4	5.7	1.3	3.8	7.7
X4	7.	7.5	3.4	4.6	14.0	105.8	45.5	52.6	159.1	4.8	1.9	2.7	7.4
X5	13.	6.1	3.0	3.1	12.6	83.1	60.4	22.0	258.2	3.6	1.3	2.0	5.9
X6	10.	8.8	6.6	4.0	25.6	93.1	36.0	48.6	146.8	3.7	2.2	1.0	7.9
X7	6.	8.0	3.7	4.7	15.1	94.9	64.5	30.3	219.9	3.7	1.9	0.5	5.8
X8	5.	9.7	11.6	3.5	30.4	86.0	62.5	44.9	193.1	4.2	3.1	1.8	9.7
X9	5.	11.0	10.6	3.7	29.7	92.0	19.7	66.9	109.9	2.9	0.8	2.2	4.0
X10	1.	4.7	0.0	4.7	4.7	49.8	0.0	49.8	49.8	2.2	0.0	2.2	2.2
X11	1.	6.7	0.0	6.7	6.7	97.5	0.0	97.5	97.5	2.6	0.0	2.6	2.6
X12	2.	8.6	7.5	3.3	13.9	131.0	114.4	50.1	211.9	0.9	0.6	0.4	1.3
CUM	74.	6.6	5.5	1.7	30.4	78.0	49.1	7.6	258.2	4.2	1.9	0.4	9.7

MI. K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	2.	2.6	0.6	2.1	3.0	36.7	21.7	21.4	52.0	4.3	0.7	3.8	4.7
CHRY	2.	2.9	1.1	2.1	3.7	38.6	40.0	10.3	66.9	4.5	2.9	2.4	6.5
DODG	4.	4.6	2.6	1.7	7.9	62.9	31.7	20.1	92.9	5.7	1.7	3.4	7.4
PLYM	5.	6.6	4.8	1.7	14.0	74.5	59.1	7.6	159.1	5.0	3.0	2.2	9.7
FORD	16.	7.7	6.8	3.1	30.4	95.9	74.4	14.2	258.2	4.1	2.1	0.5	7.4
MERC	3.	5.0	0.7	4.3	5.6	67.6	48.0	38.6	123.1	4.4	2.3	2.0	6.6
BUIC	6.	5.1	1.4	3.1	6.8	80.9	25.1	57.5	127.2	5.0	2.6	1.0	7.9
CADI	2.	4.6	1.5	3.5	5.7	97.3	9.6	90.5	104.0	4.2	0.5	3.9	4.6
CHEV	17.	7.5	6.4	3.2	29.7	82.2	45.3	32.0	211.9	3.4	1.7	0.4	6.9
OLDS	6.	7.4	3.2	3.9	12.6	93.1	39.0	36.3	152.1	4.1	1.1	2.6	5.7
PONT	7.	8.2	8.0	3.5	25.6	61.8	23.5	30.3	86.0	5.0	1.3	3.4	6.6
IMPT	1.	3.1	0.0	3.1	3.1	38.7	0.0	38.7	38.7	2.3	0.0	2.3	2.3
VW	3.	6.0	6.1	2.4	13.1	49.9	25.0	34.8	78.8	2.0	0.7	1.5	2.8
CUM	74.	6.6	5.5	1.7	30.4	78.0	49.1	7.6	258.2	4.2	1.9	0.4	9.7

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	9.	6.0	3.2	3.3	13.9	83.8	52.5	49.8	211.9	2.4	1.1	0.4	3.7
C.D.	31.	9.1	7.3	2.1	30.4	96.3	42.9	22.0	219.9	3.5	1.8	0.5	7.9
A.I.	3.	5.5	3.0	3.0	8.8	52.3	30.7	21.4	82.8	4.8	0.9	4.0	5.7
E.M.	31.	4.5	2.1	1.7	10.9	60.4	49.8	7.6	258.2	5.3	1.8	1.5	9.7
CUM	74.	6.6	5.5	1.7	30.4	78.0	49.1	7.6	258.2	4.2	1.9	0.4	9.7

```
                 MI. K.M. BEFORE SERVICE           1975 CVS TEST                - PHASE 1 DATA

                                      ALL CARS

                                          100"  CLASS
  CID   NO.           HYDROCARBON                    CARBON MONOXIDE                  NITROGEN OXIDES
  100"  CARS    MEAN   SDEV    MIN     MAX      MEAN    SDEV    MIN     MAX      MEAN   SDEV    MIN     MAX
  X1     4.      5.3    5.2    2.4    13.1      47.1    21.2   34.8    78.8       2.1    0.6    1.5     2.8
  X2     7.      4.8    0.9    4.0     6.6      62.8    22.2   30.4    88.6       2.8    1.0    2.1     5.0
  X3    16.      8.0    7.2    2.1    30.4      90.5    67.7   14.2   219.9       3.2    1.8    0.4     6.9
  X4    39.      7.0    5.6    1.7    29.7      80.3    48.5    7.6   258.2       4.8    1.9    1.0     9.7
  X5     8.      4.6    1.0    3.5     6.2      70.3    27.1   36.8   104.0       5.2    1.3    3.4     6.6
  CUM   74.      6.6    5.5    1.7    30.4      78.0    49.1    7.6   258.2       4.2    1.9    0.4     9.7

                                          1K#  CLASS
  WT    NO.           HYDROCARBON                    CARBON MONOXIDE                  NITROGEN OXIDES
  1K#   CARS    MEAN   SDEV    MIN     MAX      MEAN    SDEV    MIN     MAX      MEAN   SDEV    MIN     MAX
  X2     0.      0.0    0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0        0.0    0.0 9999.0-9999.0
  X3    10.      4.8    3.1    2.4    13.1      48.4    21.2   22.0    88.6       2.8    1.4    1.5     5.9
  X4    17.      7.2    4.2    2.1    15.1      92.6    59.8   14.2   219.9       3.8    1.9    0.4     6.9
  X5    43.      7.1    6.4    1.7    30.4      78.9    48.9    7.6   258.2       4.6    2.0    1.0     9.7
  X6     4.      4.3    0.9    3.5     5.7      79.9    27.1   41.2   104.0       4.7    0.8    3.9     5.7
  CUM   74.      6.6    5.5    1.7    30.4      78.0    49.1    7.6   258.2       4.2    1.9    0.4     9.7
```

MI. K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	3.	4.5	1.5	3.3	6.3	53.2	3.9	50.1	57.7	2.4	1.2	1.3	3.7
62-5	20.	7.2	4.6	2.1	20.1	80.3	41.3	23.5	219.9	3.0	1.2	0.5	5.1
66-7	15.	6.4	2.6	2.1	12.9	77.9	31.2	30.3	136.3	3.5	1.5	1.0	5.9
68-9	21.	4.0	1.2	1.9	6.3	48.4	26.7	10.3	143.4	5.3	2.1	1.2	9.7
70-1	15.	3.5	1.0	1.7	5.2	41.9	22.8	7.6	83.6	5.2	1.1	2.8	6.9
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

10K CLASS

MILE	NO.	HYDROCARBCN				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	4.	2.7	1.3	1.7	4.4	25.0	22.6	7.6	58.1	6.0	0.7	5.1	6.9
X2	10.	3.8	1.0	2.4	5.2	42.0	11.7	30.4	69.2	4.4	1.5	1.5	6.6
X3	10.	4.0	1.8	2.1	8.4	54.3	29.7	10.3	107.4	5.7	1.3	3.8	7.7
X4	7.	6.3	3.0	4.6	12.9	73.8	33.9	45.6	143.4	5.1	1.3	3.6	7.4
X5	13.	4.7	2.0	1.9	8.2	57.3	34.5	22.0	136.3	3.1	1.3	1.2	5.9
X6	10.	6.8	3.3	4.0	15.5	79.9	27.2	43.8	127.2	3.9	2.2	1.0	7.9
X7	6.	7.3	4.3	2.1	15.1	82.6	71.2	23.5	219.9	3.7	1.8	0.5	5.0
X8	5.	4.5	1.6	2.5	6.2	59.3	26.8	28.3	90.1	4.8	2.8	3.1	9.7
X9	5.	5.6	1.4	3.7	7.0	71.3	6.1	62.8	76.8	2.6	0.7	1.7	3.6
X10	1.	4.7	0.0	4.7	4.7	49.8	0.0	49.8	49.8	2.2	0.0	2.2	2.2
X11	1.	6.7	0.0	6.7	6.7	97.5	0.0	97.5	97.5	2.6	0.0	2.6	2.6
X12	2.	11.7	11.9	3.3	20.1	80.2	42.5	50.1	110.2	1.4	0.2	1.3	1.5
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

MI. K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
AMC	2.	2.6	0.6	2.1	3.0	36.7	21.7	21.4	52.0	4.3	0.7	3.8	4.7
CHRY	2.	2.9	1.1	2.1	3.7	38.6	40.0	10.3	66.9	4.5	2.9	2.4	6.5
DODG	4.	3.3	1.7	1.7	5.2	40.0	21.1	20.1	58.9	5.6	0.8	4.3	6.2
PLYM	5.	6.4	4.4	1.7	12.9	59.6	38.1	7.6	107.4	5.4	2.8	2.2	9.7
FORD	16.	5.7	3.1	2.5	15.1	74.6	54.8	14.2	219.9	4.2	2.0	0.5	7.4
MERC	3.	5.1	0.7	4.3	5.7	62.5	39.1	38.6	107.7	4.4	2.3	2.1	6.6
BUIC	6.	5.1	1.4	3.1	6.8	80.9	25.1	57.5	127.2	5.0	2.6	1.0	7.9
CADI	2.	4.2	2.0	2.8	5.7	78.8	35.7	53.5	104.0	4.1	0.7	3.6	4.6
CHEV	17.	5.8	3.9	3.2	20.1	59.4	21.8	32.0	110.2	3.5	1.5	1.3	5.8
OLDS	5.	5.2	1.0	3.9	6.7	71.4	21.6	36.3	97.5	3.7	1.0	2.6	5.7
PONT	[illegible]	6.3	4.5	2.1	15.5	48.1	17.9	30.3	77.5	5.0	1.3	3.1	6.6
IMPT	1.	1.9	0.0	1.9	1.9	23.8	0.0	23.8	23.8	1.2	0.0	1.2	1.2
VW	3.	4.2	2.8	2.4	7.4	49.6	24.4	34.8	77.7	1.9	0.8	1.3	2.8
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
N.C.	9.	6.2	5.5	2.1	20.1	59.8	28.1	23.5	110.2	2.6	1.1	1.3	4.3
C.D.	31.	6.4	3.2	2.1	15.5	80.2	36.8	22.0	219.9	3.6	1.6	0.5	7.9
A.I.	3.	3.7	0.8	3.0	4.6	36.4	15.7	21.4	52.6	4.5	0.5	4.0	4.8
E.M.	31.	4.1	1.5	1.7	7.8	46.7	26.7	7.6	143.4	5.2	1.8	1.2	9.7
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

MI. K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	4.	3.6	2.6	1.9	7.4	43.1	23.7	23.8	77.7	1.7	0.7	1.2	2.8
X2	7.	4.0	1.5	2.1	6.6	44.4	22.2	23.5	88.6	3.1	1.1	2.1	5.0
X3	16.	6.4	4.9	2.1	20.1	75.8	51.7	14.2	219.9	3.3	1.7	0.5	6.9
X4	39.	5.4	2.7	1.7	15.5	60.5	28.9	7.6	143.4	4.8	1.8	1.0	9.7
X5	8.	4.5	1.1	2.8	6.2	65.7	26.3	36.8	104.0	5.2	1.3	3.4	6.6
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	10.	4.0	1.8	1.9	7.4	44.3	22.8	22.0	88.6	2.7	1.5	1.2	5.9
X4	17.	6.6	5.1	2.1	20.1	68.6	52.6	14.2	219.9	3.8	1.7	0.5	6.9
X5	43.	5.2	2.2	1.7	15.5	62.5	27.9	7.6	143.4	4.6	1.9	1.0	9.7
X6	4.	4.1	1.2	2.8	5.7	70.6	28.5	41.2	104.0	4.6	0.8	3.6	5.7
CUM	74.	5.3	3.1	1.7	20.1	61.9	34.8	7.6	219.9	4.2	1.9	0.5	9.7

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	14.	8.9	7.5	3.2	30.1	94.9	63.3	29.3	217.4	2.2	2.2	0.4	8.9
62-5	41.	8.1	6.4	3.0	32.4	91.1	66.4	13.0	375.0	2.8	1.5	0.5	6.5
66-7	30.	7.6	6.8	1.5	30.9	79.9	32.5	15.8	134.7	2.8	1.5	0.7	6.5
68-9	37.	4.2	2.3	0.9	12.2	62.4	37.0	13.1	176.9	3.9	1.8	1.0	6.8
70-1	27.	3.7	1.8	0.9	7.8	51.4	37.8	7.9	144.0	4.2	2.2	1.0	7.9
CUM	149.	6.3	5.5	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	7.	3.0	1.0	1.6	4.4	29.4	11.3	7.9	39.8	5.8	1.9	1.8	7.5
X2	15.	5.9	4.1	2.6	20.0	70.5	33.1	26.6	120.5	3.7	1.7	1.5	7.1
X3	18.	3.7	1.7	0.9	6.8	52.8	40.8	9.5	176.9	4.0	1.9	1.6	7.9
X4	20.	4.6	2.9	0.9	12.2	70.8	38.4	13.1	144.0	3.1	1.7	1.0	6.8
X5	22.	6.5	6.0	1.5	30.9	78.4	42.1	15.8	217.4	3.0	1.7	0.5	5.5
X6	21.	5.3	3.0	1.6	16.0	72.8	60.2	17.1	299.8	3.2	1.7	0.5	6.7
X7	11.	6.2	2.5	2.4	10.3	97.0	97.3	17.9	375.0	3.0	2.2	0.7	6.6
X8	11.	6.3	3.0	3.2	12.6	79.9	35.4	38.3	142.6	2.6	2.4	0.6	8.9
X9	11.	10.7	9.7	3.4	32.4	84.3	43.9	13.0	149.9	2.2	1.4	0.8	5.2
X10	7.	8.4	3.2	4.5	13.4	113.6	57.6	41.1	211.9	3.1	1.9	0.6	6.5
X11	3.	15.0	12.7	5.7	29.5	121.2	51.5	84.6	180.1	1.8	1.2	0.4	2.6
X12	3.	19.7	14.4	3.2	30.1	80.8	28.9	48.5	104.0	2.9	1.2	2.1	4.3
CUM	149.	6.3	5.6	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	5.	3.7	1.7	1.6	5.5	42.2	27.6	17.1	82.7	3.4	1.5	1.8	5.5
CHRY	3.	5.7	3.3	3.2	9.4	67.4	33.5	41.1	105.0	3.5	2.5	1.1	6.0
DODG	8.	4.8	3.1	1.6	10.9	34.7	26.1	7.9	94.2	4.8	1.8	2.0	7.5
PLYM	9.	6.1	4.1	1.7	13.4	61.6	38.0	19.8	142.6	4.1	1.9	1.8	6.8
FORD	31.	5.5	2.6	1.6	16.0	86.8	58.3	12.4	299.8	3.4	2.2	0.5	8.9
MERC	6.	4.1	1.5	1.7	6.2	49.0	28.2	13.0	92.0	4.2	2.2	1.6	7.1
BUIC	10.	8.7	8.7	3.1	32.4	118.6	45.5	39.8	211.9	2.8	2.0	0.6	6.6
CADI	4.	5.3	2.3	2.7	8.0	94.8	30.9	60.0	122.0	4.3	2.8	1.2	7.9
CHEV	33.	7.9	7.1	2.2	29.5	73.0	34.5	24.5	180.1	3.3	1.4	0.4	6.6
OLDS	10.	7.6	8.3	1.5	30.1	101.4	100.6	15.8	375.0	3.3	1.6	1.7	6.0
PONT	12.	5.5	2.1	2.6	8.7	77.2	34.9	26.8	132.8	3.4	1.6	0.9	6.7
IMPT	6.	3.5	2.7	1.2	8.4	52.7	40.1	9.9	118.4	1.4	0.6	0.7	2.3
VW	12.	6.9	8.6	0.9	30.9	57.9	43.6	9.5	134.7	1.4	0.8	0.6	2.5
CUM	149.	6.3	5.6	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	9.	10.8	10.1	1.6	32.4	101.9	83.6	17.1	299.8	2.9	2.6	0.5	8.9
C.D.	69.	7.6	5.8	2.7	30.9	87.3	53.7	13.0	375.0	2.7	1.6	0.4	6.5
A.I.	12.	5.3	7.8	1.2	29.5	50.8	27.7	9.9	96.7	2.9	1.4	1.1	5.3
E.M.	59.	4.4	2.3	0.9	12.2	61.2	38.9	7.9	176.9	4.1	2.0	0.8	7.9
CUM	149.	6.3	5.6	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	19.	5.5	7.1	0.9	30.9	53.8	41.4	9.5	134.7	1.5	0.8	0.6	3.0
X2	13.	5.7	3.4	2.9	16.0	81.2	83.5	13.0	299.8	3.1	2.5	0.5	8.9
X3	34.	6.0	3.5	1.6	20.0	77.1	38.7	17.1	180.1	3.0	1.4	0.4	6.5
X4	64.	6.7	6.1	1.5	30.1	73.4	51.1	7.9	375.0	3.9	1.8	0.9	7.5
X5	19.	6.8	6.6	1.7	32.4	92.4	47.0	26.8	211.9	3.7	2.3	0.6	7.9
CUM	149.	6.3	5.6	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	30.	5.8	6.0	0.9	30.9	74.0	65.7	9.5	299.8	2.3	2.1	0.5	8.9
X4	40.	4.6	2.2	1.2	10.9	59.6	34.8	13.0	180.1	3.2	1.6	0.4	6.6
X5	73.	7.5	6.6	1.6	32.4	82.3	51.5	7.9	375.0	3.6	1.8	0.6	7.5
X6	6.	5.4	1.8	2.7	8.0	90.8	32.0	50.6	122.0	4.5	2.2	1.2	7.9
CUM	149.	6.3	5.6	0.9	32.4	74.9	50.9	7.9	375.0	3.3	1.9	0.4	8.9

ALL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	14.	8.8	7.5	3.2	30.1	85.4	49.1	29.3	211.9	2.2	2.2	0.4	8.9
62-5	41.	6.0	3.6	2.7	25.7	68.3	28.5	13.0	140.1	2.8	1.4	0.6	5.9
66-7	30.	5.3	2.6	1.5	13.4	65.4	29.6	8.4	140.9	3.1	1.6	0.5	6.5
68-9	37.	3.6	1.9	0.9	12.2	52.5	35.7	13.1	176.9	3.8	1.8	1.0	7.0
70-1	27.	3.4	1.6	0.9	7.0	43.5	30.3	7.9	122.9	4.3	2.3	1.5	7.9
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	7.	3.0	1.0	1.6	4.4	29.4	11.3	7.9	39.8	5.8	1.9	1.8	7.5
X2	15.	5.8	4.2	2.6	20.0	65.4	31.6	26.6	120.5	3.9	2.0	1.5	7.8
X3	18.	3.3	1.5	0.9	6.8	48.2	41.0	9.5	176.9	3.7	1.9	1.6	7.9
X4	20.	3.7	2.4	0.9	12.2	52.7	27.2	13.1	122.9	3.1	1.7	1.0	6.8
X5	22.	4.9	2.4	1.5	12.0	62.6	29.0	15.8	132.6	3.4	1.8	0.4	7.0
X6	21.	4.3	1.7	1.6	7.6	53.8	30.0	14.0	120.9	3.4	1.6	1.2	6.7
X7	11.	5.1	2.0	2.4	9.3	58.4	31.4	8.4	103.9	3.0	1.8	1.2	6.6
X8	11.	5.6	2.1	3.2	10.4	72.9	19.8	45.2	100.0	2.4	2.3	0.6	8.9
X9	11.	6.0	1.7	3.4	8.9	72.9	43.6	13.0	140.9	2.6	1.6	0.5	5.9
X10	7.	8.1	3.2	4.5	13.4	96.9	58.7	41.1	211.9	3.1	1.9	0.6	6.5
X11	3.	6.1	3.3	2.9	9.5	96.6	36.3	59.2	131.7	1.6	1.0	0.6	2.6
X12	3.	19.7	14.4	3.2	30.1	80.8	28.9	48.5	104.0	2.9	1.2	2.1	4.3
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

ALL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	5.	3.6	1.5	1.6	5.5	42.9	26.9	17.1	82.7	2.5	1.2	1.2	4.3
CHRY	3.	3.8	0.6	3.2	4.5	39.8	16.9	22.3	56.0	3.5	2.5	1.1	6.0
DODG	8.	4.0	1.9	1.6	8.0	32.1	19.6	7.9	73.6	4.7	1.8	2.0	7.5
PLYM	9.	5.9	4.1	1.7	13.4	50.2	27.3	19.8	91.1	4.3	2.0	1.8	6.8
FORD	31.	4.8	1.8	1.6	9.3	69.9	37.3	12.4	176.9	3.4	2.1	0.4	8.9
MERC	6.	3.7	1.1	1.7	4.7	39.8	18.9	13.0	68.0	4.5	2.3	1.6	7.1
BUIC	10.	5.8	2.8	3.0	11.7	104.8	47.8	39.8	211.9	2.7	2.0	0.6	6.6
CADI	4.	4.6	1.5	2.7	6.2	76.3	18.3	60.0	101.5	4.7	2.5	2.2	7.9
CHEV	33.	5.9	4.8	2.2	25.7	64.2	29.2	17.3	131.7	3.1	1.3	0.6	6.4
OLDS	10.	6.8	8.3	1.5	30.1	63.1	26.7	15.8	104.0	3.8	2.1	1.7	7.8
PONT	12.	5.4	2.0	2.6	8.7	67.2	35.3	22.5	140.9	3.8	1.8	0.9	7.0
IMPT	6.	2.6	1.3	1.2	4.0	30.2	22.4	8.4	59.9	1.8	0.5	1.0	2.5
VW	12.	4.4	3.6	0.9	12.0	44.3	26.6	9.5	94.6	1.6	0.8	0.5	2.9
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	9.	6.7	5.4	1.6	20.0	69.0	41.7	14.0	140.1	3.6	2.4	1.5	8.9
C.D.	69.	6.3	4.4	2.7	30.1	71.3	33.4	8.4	211.9	2.7	1.5	0.4	6.5
A.I.	12.	2.6	1.1	1.2	4.6	41.0	25.9	9.9	96.7	3.0	1.7	1.1	6.3
E.M.	59.	3.9	1.9	0.9	12.2	51.5	33.6	7.9	176.9	4.1	2.1	0.5	7.9
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

ALL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	19.	3.7	3.1	0.9	12.0	38.2	25.6	8.4	94.6	1.7	0.8	0.5	3.0
X2	13.	4.5	1.6	2.7	7.5	52.2	33.7	13.0	132.6	3.2	2.4	0.4	8.9
X3	34.	5.4	3.2	1.6	20.0	69.0	30.0	17.1	131.7	3.0	1.4	0.6	6.3
X4	64.	5.4	4.7	1.5	30.1	59.5	33.3	7.9	176.9	3.9	1.8	0.9	7.5
X5	19.	5.2	2.3	1.7	11.7	79.8	44.9	26.8	211.9	3.9	2.5	0.6	7.9
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	30.	4.2	2.6	0.9	12.0	49.4	33.5	8.4	132.6	2.4	2.0	0.4	8.9
X4	40.	4.2	1.8	1.2	9.5	52.5	29.6	13.0	131.7	3.2	1.7	0.6	7.0
X5	73.	6.0	4.7	1.6	30.1	69.8	37.1	7.9	211.9	3.6	1.8	0.6	7.5
X6	6.	4.5	1.3	2.7	6.2	65.6	22.2	37.8	101.5	5.2	2.3	2.2	7.9
CUM	149.	5.1	3.7	0.9	30.1	60.9	35.0	7.9	211.9	3.3	1.9	0.4	8.9

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
.57-1	15.	7.2	4.9	3.1	19.9	64.1	28.3	26.0	125.0	2.5	1.2	0.2	4.0
62-5	40.	8.8	6.9	1.9	30.4	103.0	52.8	22.4	232.5	2.4	1.2	0.3	4.9
66-7	29.	8.4	6.0	2.1	28.3	89.3	49.1	25.1	258.2	3.1	1.6	0.3	7.4
68-9	38.	4.4	1.9	1.3	9.8	60.4	34.9	10.3	152.1	4.3	2.2	0.9	9.7
70-1	27.	3.4	1.1	1.7	6.6	45.0	28.3	7.1	96.2	4.4	1.8	0.8	6.9
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	5.	2.7	1.1	1.7	4.4	23.6	19.8	7.6	58.1	5.2	1.9	1.9	6.9
X2	16.	4.0	1.8	1.7	8.9	48.4	28.0	18.6	112.3	3.7	1.9	1.1	6.9
X3	18.	3.4	1.5	1.7	8.4	45.3	26.2	7.1	107.4	4.8	1.8	1.5	7.7
X4	11.	6.3	3.4	1.3	14.0	91.9	46.9	20.4	159.1	3.9	2.3	0.8	7.4
X5	20.	5.8	2.4	3.1	12.6	83.4	50.8	22.0	258.2	3.5	1.3	2.0	5.9
X6	26.	6.9	5.1	1.7	25.6	83.3	38.6	17.4	147.4	2.7	1.9	0.2	7.9
X7	14.	8.6	6.0	3.0	21.4	85.8	46.1	30.3	219.9	3.1	1.5	0.5	5.6
X8	15.	8.6	8.6	3.1	30.4	78.8	43.5	25.1	193.1	3.4	2.1	0.4	9.7
X9	12.	9.8	7.4	3.3	29.7	97.9	64.5	22.4	232.5	2.5	1.2	0.3	4.0
X10	6.	8.7	7.6	4.2	23.8	91.0	47.1	49.8	171.9	2.1	0.9	1.0	3.6
X11	2.	7.2	0.7	6.7	7.7	96.7	1.1	96.0	97.5	2.5	0.1	2.5	2.6
X12	4.	5.6	5.6	1.9	13.9	81.9	87.1	28.0	211.9	1.9	1.4	0.4	3.8
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
AMC	5.	3.8	2.3	1.7	7.0	58.3	38.8	21.4	121.6	2.7	1.6	1.0	4.7
CHRY	3.	4.5	3.0	2.1	7.9	83.0	82.0	10.3	171.9	3.5	2.7	1.5	6.5
DODG	8.	4.1	2.0	1.7	7.9	57.0	27.0	20.1	92.9	4.7	1.7	2.4	7.4
PLYM	9.	5.2	3.8	1.7	14.0	60.0	46.4	7.6	159.1	4.2	2.4	2.2	9.7
FORD	31.	6.9	5.7	2.3	30.4	82.5	58.6	14.2	258.2	3.7	1.8	0.5	7.4
MERC	6.	7.3	8.2	1.9	23.8	60.6	34.3	37.7	123.1	3.5	1.9	2.0	6.6
BUIC	11.	5.7	2.2	3.1	10.8	98.9	32.0	57.5	147.4	3.5	2.6	0.8	7.9
CADI	4.	11.0	11.7	3.5	28.3	93.5	24.7	60.7	118.8	3.8	1.2	2.1	4.6
CHEV	32.	7.8	5.9	2.5	29.7	86.0	48.3	18.2	232.5	3.0	1.7	0.2	6.9
OLDS	10.	6.6	3.0	2.1	12.6	75.8	40.8	22.4	152.1	3.3	1.3	1.5	5.7
PONT	12.	7.3	6.2	3.5	25.6	79.9	47.1	30.3	213.9	4.1	1.7	1.3	6.6
.IMPT	6.	3.0	1.6	1.3	4.9	26.1	13.3	7.1	43.7	3.3	2.0	0.9	6.1
VW	12.	5.3	4.3	1.7	14.9	52.9	27.4	18.6	111.8	1.6	0.8	0.3	2.8
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
N.C.	12.	6.8	5.1	2.6	19.9	75.0	47.9	33.1	211.9	2.5	1.1	0.4	3.7
C.D.	65.	8.5	6.4	1.9	30.4	92.0	47.4	22.0	232.5	2.9	1.6	0.2	7.9
A.I.	15.	5.6	5.5	1.3	23.8	59.9	38.6	7.1	137.4	3.1	1.6	0.6	6.1
E.M.	57.	4.2	1.9	1.7	10.9	59.6	42.1	7.6	258.2	4.3	2.0	0.8	9.7
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	19.	4.5	3.6	1.3	14.9	43.0	26.2	7.1	111.8	2.3	1.5	0.3	6.1
X2	14.	5.2	3.3	1.9	15.6	66.1	34.8	28.0	143.6	2.7	1.1	1.0	5.0
X3	33.	7.5	6.1	1.7	30.4	91.4	57.8	14.2	232.5	2.6	1.6	0.2	6.9
X4	64.	6.4	5.0	1.7	29.7	74.3	45.7	7.6	258.2	4.1	1.9	1.0	9.7
X5	19.	7.5	6.9	2.3	28.3	87.8	37.7	25.4	171.9	3.7	1.9	0.8	6.6
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	26.	5.0	3.8	1.7	15.6	46.8	24.8	7.1	111.8	2.7	1.5	0.3	6.1
X4	46.	5.6	3.5	1.3	15.1	78.3	53.1	14.2	232.5	3.0	1.7	0.3	6.9
X5	70.	7.3	6.1	1.7	30.4	82.4	47.0	7.6	258.2	3.8	2.0	0.2	9.7
X6	7.	8.5	8.9	3.5	28.3	85.2	26.5	41.2	118.8	4.3	1.1	2.1	5.7
CUM	149.	6.4	5.3	1.3	30.4	75.0	46.8	7.1	258.2	3.4	1.9	0.2	9.7

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
57-1	15.	5.9	3.1	3.1	14.5	65.4	39.1	28.0	182.5	2.5	1.4	0.5	5.9
62-5	40.	6.4	3.6	1.9	20.1	81.4	41.1	22.4	219.9	2.5	1.2	0.4	5.1
66-7	29.	6.3	4.8	2.1	28.3	69.6	30.9	25.1	137.4	3.0	1.5	0.6	5.9
68-9	38.	3.9	1.5	1.3	8.2	53.5	34.2	10.3	147.4	4.2	2.3	0.6	9.7
70-1	27.	3.3	1.0	1.7	5.2	41.0	25.2	7.1	96.2	4.3	1.7	0.8	6.9
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	5.	2.7	1.1	1.7	4.4	23.6	19.8	7.6	58.1	5.2	1.9	1.9	6.9
X2	16.	3.7	1.2	1.7	6.4	40.9	15.4	18.6	74.6	3.5	1.8	0.9	6.6
X3	18.	3.4	1.5	1.7	8.4	44.1	26.8	7.1	107.4	4.8	1.8	1.5	7.7
X4	11.	5.5	2.8	1.3	12.9	71.5	35.8	20.4	143.4	4.1	2.1	0.8	7.4
X5	20.	4.7	1.7	1.9	8.2	64.1	35.8	22.0	143.6	3.1	1.3	1.2	5.9
X6	26.	5.9	3.4	1.7	15.5	76.4	40.2	17.4	182.5	2.9	1.9	0.5	7.9
X7	14.	6.1	3.5	2.1	15.1	77.0	53.5	23.5	219.9	3.1	1.7	0.5	5.9
X8	15.	6.3	6.3	2.5	28.3	63.4	24.5	25.1	107.1	3.6	2.0	0.6	9.7
X9	12.	5.6	1.5	3.3	7.9	70.5	33.8	22.4	159.2	2.2	1.0	0.4	4.0
X10	6.	5.1	2.1	2.1	7.9	86.2	50.1	49.4	171.9	2.0	1.0	1.0	3.6
X11	2.	6.3	0.6	5.9	6.7	76.5	29.7	55.5	97.5	2.9	0.4	2.6	3.2
X12	4.	7.1	8.7	1.9	20.1	56.5	36.9	28.0	110.2	2.2	1.1	1.3	3.8
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
AMC	5.	3.8	2.3	1.7	7.0	58.3	38.8	21.4	121.6	2.7	1.6	1.0	4.7
CHRY	3.	4.5	3.0	2.1	7.9	83.0	82.0	10.3	171.9	3.5	2.7	1.5	6.5
DODG	8.	3.5	1.5	1.7	6.0	45.6	22.0	[illegible]	85.8	4.6	1.4	2.4	6.2
PLYM	9.	5.1	3.5	1.7	12.9	51.7	30.3	7.6	107.4	4.4	2.3	2.2	9.7
FORD	[illegible]	5.3	2.6	2.3	15.1	69.4	44.5	14.2	219.9	3.3	1.8	0.5	7.4
MERC	6.	3.7	1.6	1.9	5.7	53.2	27.0	37.7	107.7	3.4	2.1	1.1	6.6
BUIC	[illegible]	5.7	2.2	3.1	10.8	98.9	32.0	57.5	147.4	3.5	2.6	0.8	7.9
CARI	4.	10.8	11.8	2.8	28.3	84.3	32.1	53.5	118.8	3.7	1.2	2.1	4.6
CHEV	32.	5.7	3.5	2.5	20.1	64.9	35.7	18.2	182.5	3.0	1.6	0.4	6.5
OLDS	10.	5.3	1.6	2.1	8.2	62.8	26.6	22.4	97.5	3.1	1.1	1.5	5.7
PONT	12.	5.6	3.5	2.1	15.5	65.0	32.0	30.3	145.3	3.8	1.9	1.3	6.6
IMPT	6.	2.8	1.6	1.3	4.9	23.6	11.8	7.1	43.7	3.1	2.1	0.9	6.1
VW	12.	3.7	1.7	1.7	7.4	41.9	17.1	18.6	77.7	1.6	0.8	0.6	3.4
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
N.C.	12.	5.9	4.9	2.1	20.1	57.2	25.2	23.5	110.2	2.9	1.4	1.3	5.9
C.D.	65.	6.4	3.9	1.9	28.3	77.4	39.6	22.0	219.9	2.9	1.6	0.4	7.9
A.I.	15.	3.6	1.7	1.3	6.7	51.2	36.3	7.1	137.4	2.9	1.6	0.6	6.1
E.M.	57.	3.9	1.5	1.7	8.2	51.1	31.5	7.6	147.4	4.1	2.0	0.5	9.7
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 1 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	19.	3.4	1.6	1.3	7.4	35.3	17.2	7.1	77.7	2.2	1.6	0.6	6.1
X2	14.	4.0	1.5	1.9	7.0	55.4	36.7	23.5	143.6	2.7	1.2	1.0	5.0
X3	33.	5.9	3.9	1.7	20.1	77.5	47.0	14.2	219.9	2.7	1.5	0.4	6.9
X4	64.	5.1	2.4	1.7	15.5	58.4	27.0	7.6	143.4	4.1	1.8	1.0	9.7
X5	19.	6.2	5.8	2.1	28.3	86.9	41.7	25.4	171.9	3.5	2.0	0.8	6.6
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	26.	3.7	1.5	1.7	7.4	39.4	18.8	7.1	88.6	2.5	1.6	0.6	6.1
X4	46.	5.0	3.6	1.3	20.1	64.3	43.6	14.2	219.9	3.0	1.6	0.4	6.9
X5	70.	5.4	2.5	1.7	15.5	69.3	35.4	7.6	182.5	3.8	2.0	0.5	9.7
X6	7.	8.4	8.9	2.8	28.3	79.9	28.8	41.2	118.8	4.3	1.1	2.1	5.7
CUM	149.	5.1	3.3	1.3	28.3	63.1	37.2	7.1	219.9	3.4	1.8	0.4	9.7

CAL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
57-1	12.	12.4	13.8	3.4	45.8	117.5	60.8	40.9	244.6	2.2	1.2	0.7	4.1
62-5	21.	10.0	4.8	3.9	22.1	122.5	43.0	53.7	228.4	2.7	1.5	0.7	5.9
66-7	14.	9.0	12.0	3.3	49.9	103.0	49.8	41.5	232.0	3.1	1.3	0.7	4.9
68-9	16.	4.2	1.5	1.5	7.6	60.9	24.5	24.7	102.7	4.8	1.6	1.9	7.9
70-1	12.	3.5	1.0	2.6	5.9	48.2	28.5	21.1	114.2	4.1	1.2	2.9	6.3
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
X1	1.	5.1	0.0	5.1	5.1	104.0	0.0	104.0	104.0	2.7	0.0	2.7	2.7
X2	5.	6.5	3.1	2.8	9.1	92.9	47.8	37.6	143.2	3.6	1.7	1.6	6.3
X3	8.	9.0	16.6	1.5	49.9	70.6	70.3	21.1	232.0	3.4	1.2	0.7	4.6
X4	8.	4.5	2.8	2.6	11.1	51.0	25.6	21.9	86.6	4.4	0.9	2.9	5.6
X5	5.	5.6	2.6	3.4	9.7	80.7	34.8	40.0	114.2	5.3	1.5	3.8	7.7
X6	10.	9.8	12.8	3.3	45.8	92.9	58.9	51.3	244.6	3.9	2.4	1.0	7.9
X7	8.	8.5	5.6	4.6	20.8	106.5	50.7	59.9	209.1	2.8	1.6	1.0	5.4
X8	9.	6.0	3.9	3.3	15.8	95.8	56.2	41.5	228.4	3.0	1.4	0.7	4.9
X9	4.	5.1	1.2	3.4	5.9	79.3	43.3	40.9	136.5	2.9	0.9	1.7	3.7
X10	9.	8.1	3.3	3.0	12.4	117.3	43.2	24.7	169.7	2.6	1.3	1.0	5.3
X11	6.	14.9	12.5	3.9	36.7	127.8	46.6	53.7	179.0	2.2	1.7	0.7	4.6
X12	2.	9.1	3.1	6.9	11.3	123.7	21.8	108.2	139.1	3.2	1.1	2.4	4.0
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

CAL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	3.	5.2	2.0	3.9	7.6	84.8	27.0	53.7	102.7	2.3	0.5	1.8	2.7
CHRY	1.	6.9	0.0	6.9	6.9	139.1	0.0	139.1	139.1	4.0	0.0	4.0	4.0
DODG	4.	5.5	4.1	2.8	11.7	78.9	56.8	41.5	163.4	4.1	1.0	3.3	5.3
PLYM	4.	5.0	1.6	4.0	7.4	86.8	32.3	58.8	133.2	3.9	1.4	2.6	5.9
FORD	15.	8.7	10.9	2.8	45.8	97.0	66.5	27.1	244.6	3.3	2.0	0.7	7.9
MERC	3.	11.6	8.2	5.0	20.8	158.3	51.8	105.6	209.1	1.3	0.8	0.7	2.2
BUIC	4.	5.3	2.0	3.5	8.0	75.2	19.0	51.2	93.7	3.9	0.9	2.9	5.1
CADI	2.	4.3	1.3	3.4	5.2	82.7	60.4	40.0	125.4	5.5	3.1	3.3	7.7
CHEV	16.	9.9	7.7	3.5	36.7	107.4	35.5	37.6	179.0	3.4	1.6	0.8	6.3
OLDS	4.	6.6	3.0	3.4	9.7	106.4	41.5	48.5	137.0	3.7	1.5	2.2	5.6
PONT	5.	6.4	2.7	4.3	11.1	96.8	50.4	21.9	149.9	4.3	1.6	1.7	5.6
IMPT	5.	12.3	21.1	1.5	49.9	72.4	89.4	26.6	232.0	3.3	1.6	0.7	4.6
VW	9.	6.1	6.2	2.2	22.1	59.2	32.9	21.1	131.2	2.5	1.3	0.7	4.3
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
C.D.	40.	11.2	10.5	3.4	49.9	118.9	50.9	40.9	244.6	2.6	1.4	0.7	5.9
A.I.	7.	4.6	2.2	1.5	8.5	87.7	46.7	27.8	149.9	4.0	1.9	2.1	7.7
E.M.	28.	4.0	1.2	2.2	7.6	57.4	26.4	21.1	114.2	4.4	1.3	1.9	7.9
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

CAL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	11.	5.5	5.7	2.2	22.1	54.3	31.5	21.1	131.2	2.6	1.2	0.7	4.3
X2	14.	8.5	12.2	1.5	49.9	89.4	58.2	27.1	232.0	2.9	1.7	0.7	6.2
X3	11.	12.8	9.4	4.3	36.7	129.5	59.3	57.4	228.4	2.4	1.4	0.7	4.9
X4	32.	7.5	7.4	2.8	45.8	100.7	44.1	32.8	244.6	3.9	1.5	1.1	7.9
X5	7.	4.6	0.9	3.4	5.4	68.6	37.9	21.9	125.4	4.7	1.7	2.7	7.7
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	20.	7.8	10.9	1.5	49.9	72.9	52.8	24.7	232.0	2.8	1.6	0.7	6.2
X4	18.	7.7	4.8	2.8	20.8	103.1	53.3	21.1	228.4	2.6	1.0	0.7	4.9
X5	35.	8.3	8.7	3.0	45.8	99.8	48.1	21.9	244.6	3.9	1.6	0.8	7.9
X6	2.	4.3	1.3	3.4	5.2	82.7	60.4	40.0	125.4	5.5	3.1	3.3	7.7
CUM	75.	7.9	8.4	1.5	49.9	93.0	51.4	21.1	244.6	3.4	1.7	0.7	7.9

CAL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
57-1	12.	10.2	9.9	3.4	34.0	98.2	45.7	40.9	208.6	2.2	1.2	1.0	4.1
62-5	21.	7.2	2.1	3.9	11.3	107.1	37.3	53.1	194.2	2.5	1.1	0.9	5.9
66-7	14.	5.7	2.1	3.3	9.7	90.0	35.2	41.5	149.9	3.1	1.1	1.8	4.9
68-9	16.	4.0	1.1	1.5	5.4	53.7	18.2	20.0	89.1	4.8	1.6	1.4	7.9
70-1	12.	3.1	0.7	1.9	4.3	38.0	19.8	21.1	86.6	4.3	1.2	2.9	6.3
CUM	75.	6.0	4.7	1.5	34.0	80.0	41.8	20.0	208.6	3.3	1.6	0.9	7.9

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	1.	5.1	0.0	5.1	5.1	104.0	0.0	104.0	104.0	2.7	0.0	2.7	2.7
X2	5.	9.7	10.2	2.8	27.4	82.0	41.3	37.6	143.2	3.3	1.9	1.6	6.3
X3	8.	3.3	1.4	1.5	5.7	42.2	22.9	21.1	86.6	3.7	0.7	2.3	4.6
X4	8.	3.8	1.5	1.9	6.4	44.6	23.6	21.9	77.8	4.1	0.8	2.9	5.3
X5	5.	5.0	2.7	3.2	9.7	66.6	32.0	40.0	111.6	5.6	1.3	4.2	7.7
X6	10.	5.8	2.2	3.3	9.4	84.7	49.7	51.3	208.6	3.9	2.4	1.0	7.9
X7	8.	5.5	1.8	4.0	9.7	82.3	25.6	55.5	136.1	2.7	1.4	1.4	5.4
X8	9.	5.5	2.5	3.3	10.9	89.1	42.7	41.5	177.9	3.1	1.4	0.9	4.9
X9	4.	5.1	1.2	3.4	5.9	79.3	43.3	40.9	136.5	2.9	0.9	1.7	3.7
X10	9.	7.0	1.9	3.5	9.7	108.1	44.5	20.0	194.2	2.3	0.9	1.0	3.5
X11	6.	10.7	11.6	3.9	34.0	103.0	43.1	53.1	149.9	2.4	1.4	1.0	4.6
X12	2.	9.1	3.1	6.9	11.3	123.7	21.8	108.2	139.1	3.2	1.1	2.4	4.0
CUM	75.	6.0	4.7	1.5	34.0	80.0	41.8	20.0	208.6	3.3	1.6	0.9	7.9

CAL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
		MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	3.	4.3	0.4	3.9	4.8	69.2	24.9	53.7	97.9	2.5	0.6	1.8	3.0
CHRY	1.	6.9	0.0	6.9	6.9	139.1	0.0	139.1	139.1	4.0	0.0	4.0	4.0
DODG	4.	5.0	3.2	2.8	9.7	86.6	72.0	41.5	194.2	3.1	1.3	1.4	4.6
PLYM	4.	5.0	1.6	4.0	7.4	84.3	34.0	58.8	133.2	4.1	1.3	2.6	5.9
FORD	15.	5.5	2.4	2.8	10.9	85.8	51.1	27.1	208.6	3.4	2.0	0.9	7.9
MERC	3.	6.0	1.1	5.0	7.1	106.4	13.1	93.8	119.9	1.7	0.6	1.0	2.2
BUIC	4.	4.7	1.1	3.5	5.7	76.0	20.2	51.2	97.1	3.6	1.4	1.7	5.1
CADI	2.	4.3	1.3	3.4	5.2	82.7	60.4	40.0	125.4	5.5	3.1	3.3	7.7
CHEV	16.	8.7	7.2	3.2	34.0	92.6	32.6	37.6	145.8	3.5	1.6	1.0	6.3
OLDS	4.	11.4	11.0	3.4	27.4	92.0	37.2	48.5	136.1	3.6	1.5	2.2	5.6
PONT	5.	5.5	0.8	4.3	6.4	93.5	51.8	21.9	149.9	4.0	1.4	1.7	5.5
IMPT	5.	3.3	1.7	1.5	5.7	32.2	10.2	21.5	46.7	3.7	1.0	2.3	4.6
V4	9.	4.0	1.6	1.9	6.9	46.6	21.4	20.0	74.1	2.4	1.0	1.0	4.3
CUM	75.	6.0	4.7	1.5	34.0	80.0	41.8	20.0	208.6	3.3	1.6	0.9	7.9

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
		MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
C.D.	40.	7.9	5.7	3.4	34.0	100.5	39.3	40.9	208.6	2.5	1.2	0.9	5.9
A.I.	7.	4.6	2.2	1.5	8.5	87.7	46.7	27.8	149.9	4.0	1.9	2.1	7.7
E.M.	23.	3.7	0.9	1.9	5.4	49.0	20.8	20.0	89.1	4.4	1.3	1.4	7.9
CUM	75.	6.0	4.7	1.5	34.0	80.0	41.8	20.0	208.6	3.3	1.6	0.9	7.9

```
                CAL IDLE SECOND SERVICE          1975 CVS TEST                  - PHASE 2 DATA


                                           ALL CARS


                                          100"  CLASS
 CID   NO.               HYDROCARBON                    CARBON MONOXIDE                  NITROGEN OXIDES
100"  CARS       MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
  X1   11.        3.6     1.6     1.9     6.9     42.5    21.2    20.0    74.1        2.6     1.1     1.0     4.3
  X2   14.        5.0     2.1     1.5     9.1     71.3    35.8    27.1   143.2        3.1     1.6     1.0     6.2
  X3   11.        9.5     8.4     4.3    34.0    102.6    35.3    57.4   177.9        2.4     1.3     0.9     4.9
  X4   32.        6.4     4.5     2.8    27.4     91.5    43.8    32.8   208.6        3.7     1.5     1.3     7.9
  X5    7.        4.6     0.9     3.4     5.4     68.6    37.9    21.9   125.4        4.7     1.7     2.7     7.7
 CUM   75.        6.0     4.7     1.5    34.0     80.0    41.8    20.0   208.6        3.3     1.6     0.9     7.9


                                           1K#  CLASS
  WT   NO.               HYDROCARBON                    CARBON MONOXIDE                  NITROGEN OXIDES
 1K#  CARS       MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
  X2    0.        0.0     0.0 9999.0-9999.0      0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0
  X3   20.        4.3     1.9     1.5     8.0     54.3    26.8    20.0   119.9        2.9     1.5     1.0     6.2
  X4   18.        5.8     2.3     2.8    10.9     87.0    38.9    21.1   177.9        2.7     1.0     0.9     4.9
  X5   35.        7.2     6.3     3.0    34.0     91.0    43.9    21.9   208.6        3.8     1.6     1.0     7.9
  X6    2.        4.3     1.3     3.4     5.2     82.7    60.4    40.0   125.4        5.5     3.1     3.3     7.7
 CUM   75.        6.0     4.7     1.5    34.0     80.0    41.8    20.0   208.6        3.3     1.6     0.9     7.9
```

CAL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
57-1	11.	7.7	4.9	3.4	22.0	119.6	70.9	49.6	289.7	2.0	1.2	0.3	3.7
62-5	22.	15.1	18.7	4.3	79.4	132.3	81.3	28.1	387.1	2.7	1.5	0.4	5.0
66-7	14.	6.0	3.9	2.1	14.9	86.1	42.4	40.5	177.5	3.1	1.6	0.6	5.8
68-9	16.	6.8	8.0	2.2	35.7	77.4	42.8	13.7	196.1	3.7	1.9	0.8	8.8
70-1	12.	4.5	3.0	1.7	11.9	43.4	28.0	5.6	97.5	3.9	1.7	2.2	7.8
CUM	75.	6.8	11.7	1.7	79.4	96.2	66.1	5.6	387.1	3.1	1.7	0.3	8.8

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
X1	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X2	4.	5.2	3.2	2.1	9.2	57.9	38.8	18.2	111.1	2.8	1.1	1.2	3.5
X3	7.	5.7	4.0	2.4	13.8	78.1	70.5	25.7	220.4	4.7	1.9	2.5	7.8
X4	5.	6.0	3.6	3.0	11.9	47.1	30.6	5.6	82.0	3.1	1.0	1.8	4.1
X5	15.	5.6	3.0	1.7	14.9	90.2	37.2	22.8	177.5	3.0	1.2	1.0	5.4
X6	9.	8.2	6.4	2.2	22.0	111.6	92.1	13.7	289.7	2.9	2.7	0.3	8.8
X7	6.	12.8	12.0	2.1	35.7	122.3	90.1	40.5	291.7	2.4	1.7	0.4	4.7
X8	11.	12.7	22.4	2.8	79.4	97.6	41.5	35.2	189.6	3.5	1.6	1.6	5.9
X9	9.	10.4	13.4	3.6	45.8	132.6	104.7	53.0	387.1	2.3	1.4	0.4	4.3
X10	5.	14.4	19.2	5.0	46.8	89.9	45.9	51.5	158.3	3.3	1.2	1.6	4.4
X11	3.	8.2	6.1	3.4	15.0	103.0	46.5	49.6	144.3	1.8	1.0	0.8	2.7
X12	1.	7.7	0.0	7.7	7.7	87.9	0.0	87.9	87.9	3.7	0.0	3.7	3.7
CUM	75.	8.8	11.7	1.7	79.4	96.2	66.1	5.6	387.1	3.1	1.7	0.3	8.8

```
                  CAL K.M. BEFORE SERVICE          1975 CVS TEST               - PHASE 2 DATA

                                              ALL CARS

                                             MAKE  CLASS
VEH.  NO.                HYDROCARBON                      CARBON MONOXIDE                       NITROGEN OXIDES
MAKE CARS        MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX        MEAN    SDEV     MIN     MAX
AMC     3.        7.3     3.4     4.3    11.0     133.6    60.8    74.6   196.1         2.0     1.9     0.8     4.1
CHRY    1.       13.8     0.0    13.8    13.8     220.4     0.0   220.4   220.4         2.5     0.0     2.5     2.5
DODG    4.        4.3     1.9     2.7     7.1      59.2    36.1    13.7   101.5         4.7     1.1     3.8     6.4
PLYM    4.        9.7     5.0     4.3    14.9     176.6    82.4   104.5   291.7         1.8     1.4     0.4     3.4
FORD   15.        5.4     2.1     2.4     9.2      82.0    46.3    25.7   173.0         3.6     2.3     1.0     8.8
MERC    3.       30.6    42.3     6.0    79.4     118.1    68.6    53.0   189.6         2.6     2.0     1.2     4.9
BUIC    4.        5.9     1.7     4.4     7.5     120.0    33.0    91.4   167.3         2.4     1.0     0.9     3.2
CADI    2.        3.2     0.6     2.8     3.7      55.6     7.2    50.5    60.7         5.8     0.0     5.8     5.9
CHEV   16.        7.1     5.3     3.0    22.0      85.4    60.9    30.9   289.7         3.5     1.3     0.3     5.2
OLDS    4.       16.6    21.6     2.1    48.8     102.3    50.3    40.5   158.3         3.8     0.4     3.6     4.4
PONT    5.       14.3    17.7     4.7    45.8     153.9   132.5    57.3   387.1         1.9     0.9     0.4     2.6
IMPT    5.       13.1    13.7     2.1    35.7      60.1    65.3     5.6   169.3         2.4     1.1     0.6     3.4
 VW     9.        5.7     4.0     1.7    15.0      70.2    28.2    22.8   115.0         2.1     1.0     0.8     3.9
CUM    75.        8.8    11.7     1.7    79.4      96.2    66.1     5.6   387.1         3.1     1.7     0.3     8.8


                                             CTRL  CLASS
EMIS  NO.                HYDROCARBON                      CARBON MONOXIDE                       NITROGEN OXIDES
CTRL CARS        MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX        MEAN    SDEV     MIN     MAX
N.C.    0.        0.0     0.0 9999.0-9999.0         0.0     0.0 9999.0-9999.0          0.0     0.0 9999.0-9999.0
C.D.   38.       11.9    14.9     3.4    79.4     124.9    73.5    28.1   387.1         2.4     1.4     0.3     5.0
A.I.    8.        7.6    11.4     2.1    35.7      66.5    22.3    40.5   108.1         3.9     1.6     2.1     5.9
E.M.   29.        5.1     3.1     1.7    14.9      66.9    45.0     5.6   196.1         3.7     1.8     0.8     8.8
CUM    75.        8.8    11.7     1.7    79.4      96.2    66.1     5.6   387.1         3.1     1.7     0.3     8.8
```

```
                    CAL K.M. BEFORE SERVICE           1975 CVS TEST                 - PHASE 2 DATA

                                         ALL CARS

                                      100"  CLASS
 CID   NO.            HYDROCARBON                     CARBON MONOXIDE                     NITROGEN OXIDES
100"  CARS     MEAN   SDEV     MIN      MAX      MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
 X1    11.      6.0    4.2     1.7     15.0      59.6    34.6     5.6   115.0        2.3     0.9     0.8     3.9
 X2    13.      7.9    8.8     2.2     35.7      77.8    40.2    29.4   169.3        2.9     1.9     0.6     7.8
 X3    10.     12.6   23.5     2.7     79.4      84.4    54.5    13.7   189.6        2.9     1.1     1.1     4.5
 X4    34.      8.2    8.0     2.1     45.8     115.8    79.2    25.7   387.1        3.3     1.9     0.3     8.8
 X5     7.     13.0   16.2     2.8     48.8     109.6    62.7    50.5   220.4        3.8     1.6     1.8     5.9
 CUM   75.      8.8   11.7     1.7     79.4      96.2    66.1     5.6   387.1        3.1     1.7     0.3     8.8

                                       1K#  CLASS
 WT    NO.            HYDROCARBON                     CARBON MONOXIDE                     NITROGEN OXIDES
 1K#  CARS     MEAN   SDEV     MIN      MAX      MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
 X2     0.      0.0    0.0 9999.0-9999.0          0.0     0.0 9999.0-9999.0          0.0     0.0 9999.0-9999.0
 X3    20.      7.6    7.7     1.7     35.7      73.4    48.6     5.6   196.1        2.4     1.6     0.6     7.8
 X4    21.      8.7   16.3     2.4     79.4      79.0    48.2    13.7   189.6        3.2     1.3     0.9     5.4
 X5    32.     10.1   10.7     2.1     48.8     124.4    77.6    30.9   387.1        3.2     1.8     0.3     8.8
 X6     2.      3.2    0.6     2.8      3.7      55.6     7.2    50.5    60.7        5.8     0.0     5.8     5.9
 CUM   75.      8.8   11.7     1.7     79.4      96.2    66.1     5.6   387.1        3.1     1.7     0.3     8.8
```

```
              CAL K.M. SECOND SERVICE          1975 CVS TEST              - PHASE 2 DATA

                                     ALL CARS

                                    YEAR  CLASS
      NO.             HYDROCARBON                      CARBON MONOXIDE                       NITROGEN OXIDES
YEAR CARS       MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
57-1  11.        6.1     2.1     3.2    10.3     85.3    38.1    34.2   173.0        2.6     1.4     1.0     5.3
62-5  22.        7.1     3.1     4.3    17.1     91.2    46.0    28.1   241.8        2.8     1.3     1.0     6.1
66-7  14.        4.5     1.4     2.1     7.1     64.7    20.7    36.9   108.1        3.4     1.4     1.2     5.8
68-9  16.        4.1     1.5     2.2     8.0     64.2    32.2    13.7   122.7        3.7     1.8     1.8     8.8
70-1  12.        3.3     1.0     1.7     4.8     35.2    22.0     8.8    91.4        3.9     1.4     2.2     6.7
CUM   75.        5.2     2.5     1.7    17.1     70.7    39.1     8.8   241.8        3.3     1.5     1.0     8.8


                                     10K  CLASS
MILE  NO.             HYDROCARBON                      CARBON MONOXIDE                       NITROGEN OXIDES
 10K CARS       MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX       MEAN    SDEV     MIN     MAX
  X1   0.        0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0
  X2   4.        4.3     2.0     2.1     6.2     51.5    27.7    18.2    85.8        2.7     1.0     1.2     3.5
  X3   7.        4.8     2.4     2.4     8.1     62.6    46.6    21.7   133.9        4.6     1.5     3.0     6.7
  X4   5.        3.2     0.4     2.6     3.6     31.2    22.8     8.8    69.1        3.1     1.0     1.8     4.1
  X5  15.        4.5     1.2     1.7     6.2     70.3    29.3    22.8   118.8        3.4     1.3     1.0     5.4
  X6   9.        5.4     2.4     2.2    10.3     65.5    33.5    13.7   122.2        3.3     2.4     1.0     8.8
  X7   6.        5.0     2.2     2.1     6.8     61.3    20.2    33.9    79.6        2.8     1.1     1.3     4.3
  X8  11.        6.0     3.9     2.8    17.1     83.4    35.8    34.4   148.5        3.7     1.8     1.8     6.1
  X9   9.        5.9     3.0     3.2    12.5    100.7    65.4    34.2   241.8        2.7     1.3     1.0     4.7
 X10   5.        6.1     1.0     5.0     7.3     80.3    30.4    51.5   115.5        2.8     1.1     1.8     4.2
 X11   3.        7.1     4.9     3.4    12.7     58.4    18.2    46.2    79.3        2.5     0.6     1.9     3.0
 X12   1.        7.7     0.0     7.7     7.7     87.9     0.0    87.9    87.9        3.7     0.0     3.7     3.7
 CUM  75.        5.2     2.5     1.7    17.1     70.7    39.1     8.8   241.8        3.3     1.5     1.0     8.8
```

CAL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	3.	5.0	0.3	4.3	5.9	90.1	27.8	73.4	122.2	2.3	1.6	1.0	4.1
CHRY	1.	8.1	0.0	8.1	8.1	133.9	0.0	133.9	133.9	3.0	0.0	3.0	3.0
DODG	4.	4.3	1.9	2.7	7.1	59.2	36.1	13.7	101.5	4.7	1.1	3.8	6.4
PLYM	4.	5.2	0.9	4.3	6.3	72.6	25.5	44.2	104.5	3.7	1.5	1.7	5.3
FORD	15.	4.7	1.7	2.4	8.3	66.2	41.8	19.9	173.0	3.6	2.0	1.0	8.8
MERC	3.	9.6	6.5	5.6	17.1	94.0	49.2	53.0	148.5	2.8	2.2	1.2	5.4
BUIC	4.	5.3	1.2	4.4	7.1	98.9	14.7	82.7	115.5	2.8	0.4	2.3	3.2
CADI	2.	3.2	0.5	2.8	3.7	55.6	7.2	50.5	60.7	5.8	0.0	5.8	5.9
CHEV	16.	5.2	1.8	3.0	10.3	62.6	23.6	30.9	101.9	3.7	1.2	2.0	6.1
OLDS	4.	6.3	2.8	2.1	8.0	90.4	36.3	40.5	122.7	3.2	0.9	1.9	3.7
PONT	5.	6.8	3.3	4.7	12.5	113.0	79.6	38.2	241.8	2.1	0.7	1.0	2.8
IMPT	5.	3.3	2.1	2.1	7.1	38.2	31.2	8.8	89.3	2.6	0.9	1.2	3.4
VW	9.	4.8	3.2	1.7	12.7	51.9	19.9	22.8	79.6	2.3	0.8	1.3	3.9
CUM	75.	5.2	2.5	1.7	17.1	70.7	39.1	8.8	241.8	3.3	1.5	1.0	8.8

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
C.D.	38.	6.6	2.7	3.2	17.1	86.1	41.4	28.1	241.8	2.8	1.3	1.0	6.1
A.I.	8.	3.4	1.0	2.1	4.7	62.4	25.1	33.9	108.1	3.9	1.6	2.1	5.9
E.M.	29.	3.9	1.4	1.7	8.0	52.7	30.9	8.8	122.7	3.8	1.6	1.8	8.8
CUM	75.	5.2	2.5	1.7	17.1	70.7	39.1	8.8	241.8	3.3	1.5	1.0	8.8

CAL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID 100"	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
X1	11.	4.4	3.0	1.7	12.7	44.9	23.7	8.8	79.6	2.4	0.8	1.3	3.9
X2	13.	4.6	1.6	2.2	7.1	65.4	33.5	21.7	122.2	3.0	1.7	1.0	6.7
X3	10.	6.1	4.0	2.7	17.1	67.1	36.6	13.7	148.5	3.3	1.1	1.8	5.3
X4	34.	5.4	2.2	2.1	12.5	79.7	43.2	19.9	241.8	3.6	1.6	1.0	8.8
X5	7.	5.7	2.2	2.8	8.1	82.0	39.0	38.2	133.9	3.5	1.7	1.8	5.9
CUM	75.	5.2	2.5	1.7	17.1	70.7	39.1	8.8	241.8	3.3	1.5	1.0	8.8

1K# CLASS

WT 1K#	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	20.	4.4	2.5	1.7	12.7	52.6	28.8	8.8	118.8	2.6	1.3	1.0	6.7
X4	21.	5.2	3.0	2.4	17.1	62.4	34.5	13.7	148.5	3.5	1.1	1.0	5.4
X5	32.	5.9	2.1	2.1	12.5	88.3	42.2	30.9	241.8	3.4	1.7	1.0	8.8
X6	2.	3.2	0.6	2.8	3.7	55.6	7.2	50.5	60.7	5.8	0.0	5.8	5.9
CUM	75.	5.2	2.5	1.7	17.1	70.7	39.1	8.8	241.8	3.3	1.5	1.0	8.8

MI. IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

		HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	NO. CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	3.	7.6	4.8	3.7	12.9	71.4	27.9	46.7	101.7	4.0	0.5	3.5	4.4
62-5	20.	14.6	15.1	4.0	53.0	113.4	41.4	53.8	200.3	3.7	1.8	1.1	7.3
66-7	16.	8.9	4.8	3.4	22.4	110.6	35.7	34.8	162.1	3.2	1.3	1.3	5.2
68-9	21.	5.7	3.5	2.1	17.1	63.3	35.0	16.8	157.5	4.8	1.5	1.1	7.8
70-1	15.	4.4	2.1	1.6	10.9	59.1	28.7	16.9	114.6	4.5	1.4	2.3	7.4
CUM	75.	8.6	9.2	1.6	53.0	86.2	42.9	16.8	200.3	4.1	1.6	1.1	7.8

10K CLASS

		HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MILE 10K	NO. CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	6.	3.8	0.9	2.7	5.2	44.9	20.6	16.9	62.9	5.0	1.0	3.4	5.9
X2	7.	3.6	1.3	1.6	5.0	48.7	23.0	19.5	77.7	5.4	1.8	2.9	7.8
X3	10.	5.9	2.9	2.6	10.9	76.1	45.6	16.8	157.5	4.8	1.5	2.3	7.2
X4	7.	6.9	5.2	2.1	17.1	79.1	34.9	33.2	130.6	3.8	1.8	1.1	5.5
X5	8.	8.1	4.9	2.9	17.0	106.4	56.7	37.8	167.7	3.5	1.0	2.4	5.5
X6	13.	11.9	12.8	3.2	53.0	100.9	35.8	36.7	151.4	4.0	1.7	1.2	6.5
X7	9.	11.6	15.4	3.4	52.2	84.9	24.2	34.8	120.6	3.6	1.1	2.2	5.1
X8	6.	7.9	3.5	4.0	13.4	89.3	16.0	76.1	118.8	3.7	1.9	1.3	6.8
X9	5.	11.3	6.4	6.3	22.4	132.4	45.5	62.1	170.7	2.7	1.5	1.1	4.9
X10	2.	23.7	24.9	6.0	41.3	133.0	95.1	65.7	200.3	2.7	2.1	1.3	4.2
X11	2.	6.9	1.6	5.7	8.1	74.4	29.1	53.8	95.0	5.9	1.9	4.6	7.3
X12	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
CUM	75.	8.6	9.2	1.6	53.0	85.2	42.9	16.8	200.3	4.1	1.6	1.1	7.8

MI. IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	2.	8.6	3.2	6.4	10.9	88.2	16.5	76.5	99.9	4.2	1.4	3.3	5.2
CHRY	2.	25.9	21.8	10.4	41.3	178.9	30.2	157.5	200.3	2.7	2.0	1.3	4.1
DODG	4.	3.6	0.3	3.2	4.0	62.3	20.9	40.0	84.6	4.8	1.4	2.9	5.8
PLYM	5.	5.7	2.4	3.0	9.4	75.2	47.7	20.8	151.4	4.1	1.4	2.2	5.5
FORD	16.	6.0	3.1	2.7	12.5	76.5	48.8	19.5	170.7	4.3	1.5	1.2	7.4
MERC	4.	6.8	4.7	3.1	13.4	73.9	45.0	22.0	118.8	4.3	2.0	2.2	6.1
BUIC	6.	6.7	2.5	2.6	9.6	100.8	56.8	16.8	167.7	4.1	1.6	1.8	6.3
CADI	2.	3.9	3.3	1.6	6.3	84.8	86.9	23.4	145.2	3.4	2.3	1.8	5.0
CHEV	17.	11.5	11.8	2.7	53.0	86.9	32.2	16.9	149.3	4.2	1.6	2.3	7.3
OLDS	6.	14.3	19.3	4.0	52.2	91.6	39.7	58.3	167.1	3.5	1.2	2.1	5.5
PONT	7.	8.1	3.2	5.0	12.6	98.7	32.4	62.1	155.9	5.0	2.1	1.1	7.8
IMPT	1.	6.3	0.0	6.3	6.3	102.7	0.0	102.7	102.7	1.1	0.0	1.1	1.1
VW	3.	5.5	4.4	2.1	10.4	63.7	31.0	53.2	95.2	2.8	1.4	1.3	3.9
CUM	75.	8.6	9.2	1.6	53.0	86.2	42.9	16.8	200.3	4.1	1.6	1.1	7.8

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	3.	5.6	1.7	3.7	7.1	71.9	28.8	46.7	103.2	3.3	1.0	2.2	4.2
C.D.	37.	12.0	11.9	2.1	53.0	109.9	40.1	33.2	200.3	3.6	1.6	1.1	7.3
A.I.	2.	9.3	11.0	1.6	17.1	32.8	13.3	23.4	42.2	5.2	0.4	5.0	5.5
E.M.	33.	5.0	2.3	2.6	10.9	64.1	32.3	16.8	157.5	4.7	1.5	1.1	7.8
CUM	75.	8.6	9.2	1.6	53.0	86.2	42.9	16.8	200.3	4.1	1.6	1.1	7.8

```
                     MI. IDLE BEFORE SERVICE          1975 CVS TEST              - PHASE 2 DATA

                                         ALL CARS

                                          100"  CLASS
                                                   CARBON MONOXIDE                     NITROGEN OXIDES
 CID   NO.             HYDROCARBON                                                MEAN    SDEV     MIN     MAX
 100"  CARS     MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
  X1    3.       5.5     4.4     2.1    10.4      63.7    31.0    33.2    95.2     2.8     1.4     1.3     3.9
  X2    7.       4.8     1.6     2.7     7.1      72.7    30.3    19.5   103.2     2.9     1.1     1.1     4.5
  X3   19.       8.7     5.2     2.8    22.4      86.7    41.7    34.8   170.7     4.0     1.4     1.2     6.8
  X4   38.       9.2    10.9     2.6    53.0      85.7    42.4    16.8   167.1     4.5     1.6     1.1     7.8
  X5    8.       9.9    12.9     1.6    41.3     107.6    59.5    23.4   200.3     3.9     2.2     1.3     7.4
 CUM   75.       8.6     9.2     1.6    53.0      86.2    42.9    16.8   200.3     4.1     1.6     1.1     7.8

                                           1K#  CLASS
                                                   CARRON MONOXIDE                     NITROGEN OXIDES
  WT   NO.             HYDROCARBON                                                MEAN    SDEV     MIN     MAX
 1K#  CARS      MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
  X2    0.       0.0     0.0 9999.0-9999.0         0.0     0.0 9999.0-9999.0       0.0     0.0 9999.0-9999.0
  X3    8.       4.9     2.8     2.1    10.4      62.5    33.7    19.5   103.2     2.9     1.3     1.1     4.7
  X4   25.       8.6     9.5     2.9    52.2      83.5    39.7    34.8   170.7     3.7     1.3     1.1     5.8
  X5   38.       9.5    10.0     2.6    53.0      92.0    44.5    16.8   200.3     4.6     1.7     1.3     7.8
  X6    3.       6.1     4.4     1.6    10.4     100.0    66.9    23.4   146.2     4.1     2.0     1.8     5.4
 CUM   75.       8.6     9.2     1.6    53.0      86.2    42.9    16.8   200.3     4.1     1.6     1.1     7.8
```

MT. IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	3.	7.6	4.8	3.7	12.9	71.4	27.9	46.7	101.7	4.0	0.5	3.5	4.4
62-5	20.	8.4	5.6	3.2	29.7	91.3	36.1	32.0	167.7	3.7	1.5	1.1	6.8
66-7	16.	7.9	4.6	3.4	22.4	103.2	35.3	34.0	162.1	3.3	1.3	1.6	5.2
68-9	21.	5.2	3.5	2.1	17.1	51.9	32.9	16.8	157.5	5.3	1.6	2.2	9.2
70-1	15.	3.7	1.0	1.6	5.4	49.6	23.4	16.9	90.8	4.8	1.7	2.3	8.4
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	6.	3.8	0.9	2.7	5.2	44.9	20.6	16.9	62.9	5.0	1.0	3.4	5.9
X2	7.	3.5	1.2	1.6	5.0	43.1	21.9	19.5	77.7	5.6	2.1	2.9	9.2
X3	10.	5.0	2.4	2.6	10.4	61.2	45.2	16.8	157.5	5.2	1.8	2.3	8.4
X4	7.	5.9	5.1	2.1	17.1	67.5	24.1	33.2	98.4	4.0	1.6	2.1	5.6
X5	8.	6.0	2.4	2.9	9.6	89.7	46.9	37.8	167.7	3.7	0.8	2.9	5.5
X6	13.	8.8	6.8	3.2	29.7	80.6	44.9	20.1	151.4	4.3	2.0	1.2	7.8
X7	9.	6.8	3.4	3.4	13.7	75.1	28.1	34.8	120.6	3.7	1.1	2.5	5.4
X8	6.	7.1	3.3	4.0	13.4	87.1	15.9	76.1	118.8	3.7	1.8	1.6	6.8
X9	5.	10.1	7.4	3.2	22.4	104.7	57.1	32.0	162.1	3.0	1.7	1.1	4.9
X10	2.	7.4	1.9	6.0	8.7	99.6	47.9	63.7	133.5	4.0	0.3	3.8	4.2
X11	2.	6.4	0.9	5.7	7.0	92.1	4.1	89.2	95.0	5.1	0.7	4.6	5.6
X12	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

MI. IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	2.	8.0	2.4	6.4	9.7	59.9	56.4	20.1	99.8	4.7	0.8	4.1	5.2
CHRY	2.	9.6	1.2	8.7	10.4	145.5	17.0	133.5	157.5	3.9	0.2	3.8	4.1
DODG	4.	3.6	0.3	3.2	4.0	62.3	20.9	40.0	84.6	4.8	1.4	2.9	5.8
PLYM	5.	5.7	2.4	3.0	9.4	75.2	47.7	20.8	151.4	4.1	1.4	2.2	5.5
FORD	16.	5.1	2.1	2.7	9.0	64.5	36.9	19.5	150.1	4.7	1.7	1.2	7.8
MERC	4.	6.2	4.9	3.1	13.4	64.2	40.5	22.0	118.8	4.5	1.7	3.0	6.1
BUIC	6.	6.1	2.5	2.6	9.0	96.6	58.0	16.8	167.7	4.3	1.8	1.8	6.4
CADI	2.	3.9	3.3	1.6	6.3	84.8	86.9	23.4	146.2	3.4	2.3	1.8	5.0
CHEV	17.	8.1	5.1	2.7	22.4	75.2	32.0	16.9	120.6	4.2	1.5	2.3	7.2
OLDS	6.	6.1	3.3	4.0	13.7	79.3	17.5	58.3	99.7	3.4	1.2	2.1	5.5
PONT	7.	9.2	9.4	3.5	29.7	65.1	45.9	29.9	155.9	5.2	2.9	1.1	9.2
IMPT	1.	3.7	0.0	3.7	3.7	63.8	0.0	63.8	63.8	2.2	0.0	2.2	2.2
V4	3.	3.9	1.9	2.1	5.8	59.4	24.6	33.2	82.1	3.0	1.2	1.6	3.9
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	3.	4.8	1.2	3.7	6.0	58.9	10.6	46.7	65.7	3.6	0.5	3.1	4.2
C.D.	37.	8.2	5.1	2.1	29.7	95.9	36.4	32.0	167.7	3.5	1.4	1.1	6.8
A.I.	2.	9.3	11.0	1.6	17.1	32.8	13.3	23.4	42.2	5.2	0.4	5.0	5.5
E.M.	33.	4.4	1.3	2.6	10.4	52.6	29.7	16.8	157.5	5.1	1.7	2.2	9.2
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

41. IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID 100"	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	3.	3.9	1.9	2.1	5.8	59.4	24.6	33.2	82.1	3.0	1.2	1.6	3.9
X2	7.	4.0	1.0	2.7	5.9	61.6	22.2	19.5	84.6	3.2	0.7	2.2	4.5
X3	19.	7.7	5.1	2.8	22.4	71.0	34.7	20.1	140.3	4.2	1.4	1.2	6.8
X4	38.	6.7	4.7	2.6	29.7	73.6	41.8	16.8	162.1	4.6	1.8	1.1	9.2
X5	8.	5.4	2.0	1.6	9.6	96.3	49.1	23.4	167.7	4.4	2.0	1.8	7.4
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

1K* CLASS

CID 1K*	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	9.	3.7	1.2	2.1	5.8	51.1	20.7	19.5	82.1	3.2	1.0	1.6	4.7
X4	26.	6.9	3.7	2.9	17.1	76.7	37.8	20.1	162.1	3.9	1.6	1.1	7.8
X5	38.	6.9	5.2	2.6	29.7	75.4	41.0	16.9	167.7	4.8	1.7	2.1	9.2
X6	3.	4.6	2.6	1.6	6.3	85.9	61.5	23.4	146.2	4.1	2.1	1.8	5.6
CUM	75.	6.4	4.4	1.6	29.7	73.7	39.1	16.8	167.7	4.3	1.7	1.1	9.2

MI. K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
57-1	3.	4.6	1.1	3.8	5.6	60.2	36.7	35.6	102.5	4.7	1.9	2.6	6.4
62-5	20.	10.7	12.3	3.6	60.1	104.9	43.2	42.7	216.5	3.3	1.3	0.9	5.8
66-7	16.	7.0	2.8	3.6	13.1	101.3	28.5	57.2	159.8	3.7	1.7	1.3	6.4
68-9	21.	4.8	2.5	2.5	12.5	73.0	46.3	9.1	229.9	4.3	1.6	2.1	7.6
70-1	15.	4.3	1.6	2.6	9.5	67.1	31.6	25.1	117.5	4.4	1.1	2.7	6.5
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	HYDROCARBON SDEV	HYDROCARBON MIN	HYDROCARBON MAX	CARBON MONOXIDE MEAN	CARBON MONOXIDE SDEV	CARBON MONOXIDE MIN	CARBON MONOXIDE MAX	NITROGEN OXIDES MEAN	NITROGEN OXIDES SDEV	NITROGEN OXIDES MIN	NITROGEN OXIDES MAX
X1	3.	3.8	1.1	2.8	5.0	56.4	51.4	25.1	115.8	4.8	1.4	3.8	6.4
X2	3.	3.1	0.5	2.6	3.4	72.4	42.0	34.3	117.5	2.9	0.2	2.7	3.2
X3	8.	5.7	2.3	3.5	10.5	89.1	38.5	53.4	153.3	4.2	1.7	0.9	6.5
X4	12.	5.2	2.8	2.5	12.5	78.2	57.9	16.1	229.9	4.2	1.3	2.1	6.9
X5	9.	4.4	1.7	2.8	7.5	63.3	28.8	9.1	101.0	4.6	1.7	2.6	7.6
X6	11.	6.9	2.9	3.6	11.9	94.7	30.0	57.4	160.3	3.7	1.8	1.8	6.7
X7	11.	7.4	3.4	3.3	13.1	99.9	38.4	37.8	159.8	3.9	1.9	1.3	8.4
X8	9.	4.2	0.9	3.6	5.0	72.3	28.6	38.6	102.5	3.9	1.5	1.6	6.4
X9	4.	23.5	25.3	4.0	60.1	103.4	35.3	78.7	155.7	3.7	0.9	3.0	5.0
X10	3.	7.9	4.9	5.0	13.4	129.6	75.9	76.4	216.5	2.6	1.5	0.9	3.8
X11	3.	7.2	1.5	5.7	8.8	100.3	25.5	71.3	118.9	4.0	0.1	3.9	4.1
X12	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

MI. K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	2.	4.2	0.3	4.0	4.4	68.0	15.2	57.2	78.7	3.7	0.5	3.3	4.1
CHRY	2.	5.0	1.9	3.6	6.3	70.6	33.0	47.3	93.9	4.9	2.7	3.0	6.9
DODG	4.	5.8	3.3	2.8	10.5	81.1	54.6	25.1	153.3	4.6	2.1	2.4	6.5
PLYM	5.	5.2	2.2	3.4	8.8	89.4	33.3	49.5	117.5	5.0	1.6	3.2	7.6
FORD	16.	4.7	2.1	2.5	9.5	66.4	30.4	9.1	115.8	3.8	1.0	2.1	5.8
MERC	4.	5.6	2.9	3.6	9.8	80.2	36.2	37.8	118.6	3.5	1.3	1.8	4.9
BUIC	6.	8.8	3.9	3.3	12.5	145.1	47.9	95.8	229.9	3.1	0.8	2.4	4.5
CADI	2.	5.7	1.2	4.8	6.5	80.7	6.0	76.4	84.9	5.3	1.6	4.2	6.5
CHEV	17.	9.4	13.4	3.5	60.1	83.1	48.9	16.1	216.5	3.6	1.6	0.9	6.4
OLDS	6.	5.7	1.2	4.0	7.2	107.2	25.4	78.0	141.0	3.5	1.8	0.9	5.6
PONT	7.	9.4	5.5	3.5	20.5	94.7	39.4	29.2	155.7	5.3	1.7	3.5	9.4
IMPT	1.	3.2	0.0	3.2	3.2	76.0	0.0	76.0	76.0	3.6	0.0	3.6	3.6
VW	3.	3.7	1.0	2.8	4.7	60.1	6.3	53.1	65.4	2.6	0.2	2.4	2.7
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	6.	5.7	2.2	3.8	9.8	77.3	32.9	38.6	118.6	3.6	1.8	1.8	6.4
C.D.	33.	9.2	9.3	3.6	60.1	104.1	38.2	42.7	216.5	3.6	1.5	0.9	8.4
A.I.	1.	6.1	0.0	6.1	6.1	87.2	0.0	87.2	87.2	2.3	0.0	2.3	2.3
E.M.	35.	4.5	2.2	2.5	12.5	70.1	40.9	9.1	229.9	4.4	1.4	2.1	7.6
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

MI. K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	3.	3.7	1.0	2.8	4.7	60.1	6.2	53.1	65.4	2.6	0.2	2.4	2.7
X2	7.	5.9	3.2	2.6	10.5	89.0	40.6	34.3	153.3	3.1	1.0	1.8	5.1
X3	19.	5.8	3.2	2.5	13.4	78.7	46.6	25.1	216.5	3.9	1.6	0.9	6.5
X4	38.	7.5	9.4	2.8	60.1	83.9	36.5	9.1	160.2	4.3	1.5	0.9	8.4
X5	8.	7.1	3.2	4.0	12.5	119.2	51.5	76.4	229.9	3.8	1.5	2.3	6.5
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	8.	4.4	2.4	2.6	9.8	71.8	27.1	34.3	118.6	2.8	0.6	1.8	3.6
X4	26.	5.3	2.7	2.5	13.4	80.2	45.3	25.1	216.5	3.6	1.5	0.9	6.5
X5	38.	8.2	9.3	2.8	60.1	92.5	42.9	9.1	229.9	4.3	1.5	1.3	8.4
X6	3.	6.5	1.7	4.8	8.3	87.3	12.3	76.4	100.7	4.9	1.3	4.0	6.5
CUM	75.	6.7	7.0	2.5	60.1	85.8	41.8	9.1	229.9	4.0	1.5	0.9	8.4

```
              MI. K.M. SECOND SERVICE           1975 CVS TEST              - PHASE 2 DATA

                                        ALL CARS

                                       YEAR  CLASS
       NO.               HYDROCARBON              CARBON MONOXIDE                      NITROGEN OXIDES
YEAR  CARS        MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
57-1    3.         4.6     1.1     3.8     5.0     60.2    36.7    38.6   102.5       4.7     1.9     2.6     6.4
62-5   20.         6.0     2.0     2.7    11.5     81.1    34.6    17.3   149.4       3.6     1.2     0.9     6.0
66-7   16.         6.3     2.5     3.2    11.1     83.3    22.2    50.4   125.2       3.7     1.7     1.3     8.4
68-9   21.         4.2     2.1     2.0    12.5     59.0    44.5     9.1   229.9       4.4     1.6     2.1     7.6
70-1   15.         4.1     1.4     2.8     8.5     63.4    33.2    15.0   117.5       4.1     1.2     2.1     6.5
CUM    75.         5.1     2.2     2.0    12.5     71.0    36.1     9.1   229.9       4.0     1.5     0.9     8.4


                                       10K  CLASS
MILE   NO.               HYDROCARBON              CARBON MONOXIDE                      NITROGEN OXIDES
 10K  CARS        MEAN    SDEV     MIN     MAX     MEAN    SDEV     MIN     MAX      MEAN    SDEV     MIN     MAX
  X1    3.         3.8     1.1     2.8     5.0     56.4    51.4    25.1   115.8       4.8     1.4     3.8     6.4
  X2    3.         3.6     1.1     2.6     4.7     72.7    42.0    34.3   117.5       2.7     0.6     2.1     3.2
  X3    8.         4.3     0.8     3.4     6.0     67.3    35.4    15.0   141.0       4.1     1.5     0.9     6.5
  X4   12.         5.0     2.9     2.5    12.5     70.4    59.7    16.1   229.9       4.5     1.5     2.1     7.0
  X5    8.         4.2     1.2     2.8     6.3     59.8    25.2     9.1    93.9       4.6     1.8     2.6     7.6
  X6   11.         4.9     1.6     2.7     7.7     71.6    31.1    17.3   125.2       3.8     1.4     1.8     6.5
  X7   11.         6.9     3.2     2.0    11.5     76.9    32.8    35.5   149.4       3.7     1.9     1.3     8.4
  X8    9.         4.8     0.9     3.6     6.0     72.3    28.6    38.6   102.5       3.8     1.5     1.6     6.4
  X9    4.         6.0     2.9     3.2     9.5     63.2    21.3    41.7    92.4       4.0     1.0     3.1     5.0
 X10    3.         5.0     0.3     4.7     5.2     79.0    15.6    64.9    95.6       3.5     0.4     3.1     3.8
 X11    3.         7.2     1.5     5.7     8.8    100.3    25.5    71.3   118.9       4.0     0.1     3.9     4.1
 X12    0.         0.0     0.0 9999.0-9999.0      0.0     0.0 9999.0-9999.0       0.0     0.0 9999.0-9999.0
 CUM   75.         5.1     2.2     2.0    12.5     71.0    36.1     9.1   229.9       4.0     1.5     0.9     8.4
```

MI. K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH.	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
MAKE	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	2.	3.8	0.9	3.2	4.4	56.7	0.8	56.1	57.2	3.6	0.7	3.1	4.1
CHRY	2.	5.0	1.9	3.6	6.3	70.6	33.0	47.3	93.9	4.9	2.7	3.0	6.9
DODG	4.	4.3	1.1	2.8	5.5	55.4	26.1	25.1	88.5	5.0	1.9	2.4	6.5
PLYM	5.	5.2	2.2	3.4	8.8	89.4	33.3	49.5	117.5	5.0	1.6	3.2	7.6
FORD	16.	4.5	2.0	2.5	9.5	60.5	31.6	9.1	115.8	3.8	1.0	2.1	6.0
MERC	4.	3.8	0.9	2.7	4.8	54.9	35.8	17.3	100.3	3.9	0.8	3.3	4.9
BUIC	6.	7.7	4.0	2.0	12.5	123.0	64.4	35.5	229.9	3.0	1.0	1.8	4.5
CADI	2.	5.7	1.2	4.8	6.5	80.7	6.0	76.4	84.9	5.3	1.6	4.2	6.5
CHEV	17.	5.4	2.0	3.5	11.1	59.7	24.1	16.1	95.8	4.1	1.5	1.3	7.0
OLDS	6.	5.1	1.1	3.9	6.4	102.7	29.1	72.4	141.0	3.2	1.6	0.9	5.6
PONT	7.	6.0	2.5	3.5	10.1	65.8	25.4	29.2	106.0	4.8	1.7	3.3	8.4
IMPT	1.	2.5	0.0	2.5	2.5	40.8	0.0	40.8	40.8	3.6	0.0	3.6	3.6
VW	3.	4.1	1.1	2.8	4.7	60.4	6.7	53.1	66.2	2.4	0.2	2.1	2.6
CUM	75.	5.1	2.2	2.0	12.5	71.0	36.1	9.1	229.9	4.0	1.5	0.9	8.4

CTRL CLASS

EMIS	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
CTRL	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	6.	4.5	1.2	2.7	5.8	60.4	33.4	17.3	102.5	3.8	1.6	2.4	6.4
C.O.	33.	6.3	2.1	3.2	11.5	84.0	28.4	41.7	149.4	3.7	1.5	0.9	8.4
A.I.	1.	4.8	0.0	4.8	4.8	45.2	0.0	45.2	45.2	3.7	0.0	3.7	3.7
E.M.	35.	4.1	1.9	2.0	12.5	61.3	40.2	9.1	229.9	4.3	1.5	2.1	7.6
CUM	75.	5.1	2.2	2.0	12.5	71.0	36.1	9.1	229.9	4.0	1.5	0.9	8.4

[illegible]I. K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	3.	4.1	1.1	2.8	4.7	60.4	6.7	53.1	66.2	2.4	0.2	2.1	2.6
X2	7.	3.9	1.4	2.5	5.8	54.8	30.2	17.3	102.5	3.5	1.0	2.4	5.1
X3	19.	5.0	2.2	2.5	11.1	58.3	19.3	25.1	93.2	4.2	1.4	1.3	6.5
X4	38.	5.1	1.9	2.0	10.1	71.0	33.7	9.1	141.0	4.2	1.6	0.9	8.4
X5	8.	7.1	3.2	4.0	12.5	119.2	51.5	76.4	229.9	3.8	1.5	2.3	6.5
CUM	75.	5.1	2.2	2.0	12.5	71.0	36.1	9.1	229.9	4.0	1.5	0.9	8.4

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	8.	3.7	1.3	2.5	5.8	56.5	26.5	17.3	102.5	2.9	0.5	2.1	3.6
X4	26.	4.3	1.1	2.5	7.2	63.7	30.2	15.0	141.0	3.8	1.4	0.9	6.5
X5	38.	5.8	2.6	2.0	12.5	77.7	41.3	9.1	229.9	4.3	1.5	1.3	8.4
X6	3.	6.5	1.7	4.8	8.3	87.3	12.3	76.4	100.7	4.9	1.3	4.0	6.5
CUM	75.	5.1	2.2	2.0	12.5	71.0	36.1	9.1	229.9	4.0	1.5	0.9	8.4

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	15.	11.5	12.6	3.4	45.8	108.3	58.2	40.9	244.6	2.5	1.4	0.7	4.4
62-5	41.	12.3	11.2	3.9	53.0	118.0	42.0	53.7	228.4	3.2	1.7	0.7	7.3
66-7	30.	8.9	8.7	3.3	49.9	107.0	42.2	34.8	232.0	3.1	1.3	0.7	5.2
68-9	37.	5.1	2.9	1.5	17.1	62.2	30.5	16.8	157.5	4.8	1.5	1.1	7.9
70-1	27.	4.0	1.7	1.6	10.9	54.2	28.6	16.9	114.6	4.4	1.3	2.3	7.4
CUM	150.	8.2	8.9	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	7.	4.0	0.9	2.7	5.2	53.4	29.2	16.9	104.0	4.6	1.3	2.7	5.9
X2	12.	4.8	2.6	1.6	9.1	67.1	40.5	19.5	143.2	4.6	1.9	1.5	7.8
X3	18.	7.3	11.0	1.5	49.9	73.6	56.1	16.8	232.0	4.2	1.5	0.7	7.2
X4	15.	5.6	4.1	2.1	17.1	64.1	32.6	21.9	130.6	4.1	1.4	1.1	5.6
X5	13.	7.1	4.2	2.9	17.0	96.5	49.5	37.8	167.7	4.2	1.5	2.4	7.7
X6	23.	10.9	12.5	3.2	53.0	97.5	46.2	36.7	244.6	3.9	2.0	1.0	7.9
X7	17.	10.1	11.6	3.4	52.2	95.1	39.3	34.8	209.1	3.2	1.4	1.0	5.4
X8	15.	6.9	3.7	3.3	15.6	93.2	43.7	41.5	228.4	3.2	1.6	0.7	6.8
X9	9.	8.5	5.6	3.4	22.4	108.8	50.2	40.9	170.7	2.3	1.2	1.1	4.9
X10	11.	11.0	10.5	3.0	41.3	120.1	49.4	24.7	200.3	2.5	1.3	1.0	5.3
X11	3.	12.9	11.2	3.9	36.7	114.5	47.8	53.7	179.0	3.1	2.3	0.7	7.3
X12	2.	9.1	3.1	6.9	11.3	123.7	21.8	108.2	139.1	3.2	1.1	2.4	4.0
CUM	150.	8.2	8.9	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	5.	6.6	2.9	3.9	10.9	86.1	20.9	53.7	102.7	3.1	1.3	1.8	5.2
CHRY	3.	19.5	18.9	6.9	41.3	165.6	31.4	139.1	200.3	3.1	1.6	1.3	4.1
DODG	8.	4.6	2.9	2.8	11.7	70.6	40.6	40.0	163.4	4.4	1.2	2.9	5.8
PLYM	9.	5.4	2.0	3.0	9.4	80.3	39.6	20.8	151.4	4.0	1.3	2.2	5.9
FORD	31.	7.3	7.9	2.7	45.8	86.4	58.0	19.5	244.6	3.8	1.8	0.7	7.9
MERC	7.	8.9	6.3	3.1	20.8	110.0	62.8	22.0	209.1	3.0	2.2	0.7	6.1
BUIC	10.	6.1	2.3	2.6	9.6	90.5	45.7	16.8	167.7	4.0	1.3	1.8	6.3
CADI	4.	4.1	2.1	1.6	6.3	83.8	61.1	23.4	146.2	4.4	2.5	1.8	7.7
CHEV	33.	10.7	9.9	2.7	53.0	96.9	34.9	16.9	179.0	3.8	1.6	0.8	7.3
OLDS	10.	11.3	15.0	3.4	52.2	97.5	38.8	48.5	167.1	3.6	1.3	2.1	5.6
PONT	12.	7.4	3.0	4.3	12.6	97.9	38.7	21.9	155.9	4.7	1.9	1.1	7.8
IMPT	6.	11.3	19.0	1.5	49.9	77.5	80.9	26.6	232.0	2.9	1.7	0.7	4.6
VW	12.	6.0	5.6	2.1	22.1	60.4	31.1	21.1	131.2	2.6	1.2	0.7	4.3
CUM	150.	8.2	8.8	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	3.	5.6	1.7	3.7	7.1	71.9	28.8	46.7	103.2	3.3	1.0	2.2	4.2
C.D.	77.	11.6	11.1	2.1	53.0	114.6	46.0	33.2	244.6	3.0	1.6	0.7	7.3
A.I.	9.	5.7	4.8	1.5	17.1	75.5	47.3	23.4	149.9	4.3	1.7	2.1	7.7
E.M.	61.	4.5	1.9	2.2	10.9	61.0	29.7	16.8	157.5	4.6	1.4	1.1	7.9
CUM	150.	8.2	8.8	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

ALL IDLE BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	14.	5.5	5.3	2.1	22.1	56.3	30.5	21.1	131.2	2.7	1.2	0.7	4.3
X2	21.	7.3	10.1	1.5	49.9	83.8	50.4	19.5	232.0	2.9	1.5	0.7	6.2
X3	30.	10.2	7.2	2.8	36.7	102.4	52.2	34.8	228.4	3.4	1.6	0.7	6.8
X4	70.	8.4	9.4	2.6	53.0	92.5	43.5	16.8	244.6	4.2	1.6	1.1	7.9
X5	15.	7.4	9.6	1.6	41.3	89.4	52.8	21.9	200.3	4.2	1.9	1.3	7.7
CUM	150.	8.2	8.8	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	28.	7.0	9.4	1.5	49.9	70.0	47.7	19.5	232.0	2.9	1.5	0.7	6.2
X4	44.	8.2	7.9	2.8	52.2	91.5	46.2	21.1	228.4	3.3	1.3	0.7	5.8
X5	73.	8.9	9.4	2.6	53.0	95.7	46.1	16.8	244.6	4.3	1.7	0.8	7.9
X6	5.	5.4	3.3	1.6	10.4	93.1	55.9	23.4	140.2	4.6	2.2	1.8	7.7
CUM	150.	8.2	8.8	1.5	53.0	89.6	47.3	16.8	244.6	3.7	1.7	0.7	7.9

ALL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

YEAR	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
57-1	15.	9.6	9.0	3.4	34.0	92.8	43.3	40.9	208.6	2.6	1.3	1.0	4.4
62-5	41.	7.8	4.1	3.2	29.7	99.4	37.2	32.0	194.2	3.1	1.4	0.9	6.8
66-7	30.	6.9	3.8	3.3	22.4	97.1	35.3	34.8	162.1	3.2	1.2	1.6	5.2
68-9	37.	4.7	2.8	1.5	17.1	52.7	27.2	16.8	157.5	5.1	1.6	1.4	9.2
70-1	27.	3.5	0.9	1.6	5.4	44.5	22.3	16.9	90.8	4.6	1.5	2.3	8.4
CUM	150.	6.2	4.6	1.5	34.0	76.9	40.5	16.8	208.6	3.8	1.7	0.9	9.2

10K CLASS

MILE 10K	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	7.	4.0	0.9	2.7	5.2	53.4	29.2	16.9	104.0	4.6	1.3	2.7	5.9
X2	12.	6.1	7.0	1.6	27.4	59.3	35.8	19.5	143.2	4.6	2.3	1.6	9.2
X3	18.	4.3	2.1	1.5	10.4	52.8	37.3	16.8	157.5	4.5	1.6	2.3	8.4
X4	15.	4.8	3.6	1.9	17.1	55.3	25.8	21.9	98.4	4.1	1.2	2.1	5.6
X5	13.	5.6	2.5	2.9	9.7	80.8	41.9	37.8	167.7	4.5	1.4	2.9	7.7
X6	23.	7.5	5.5	3.2	29.7	82.4	46.0	20.1	208.6	4.1	2.1	1.0	7.9
X7	17.	6.2	2.8	3.4	13.7	78.5	26.3	34.8	136.1	3.2	1.4	1.4	5.4
X8	15.	6.1	2.8	3.3	13.4	88.3	33.7	41.5	177.9	3.3	1.5	0.9	6.8
X9	9.	7.9	5.9	3.2	22.4	93.4	50.1	32.0	162.1	2.9	1.3	1.1	4.9
X10	11.	7.0	1.8	3.5	9.7	106.5	42.7	20.0	194.2	2.6	1.1	1.0	4.2
X11	8.	9.6	10.0	3.9	34.0	100.3	36.8	53.1	149.9	3.0	1.7	1.0	5.6
X12	2.	9.1	3.1	6.9	11.3	123.7	21.8	108.2	139.1	3.2	1.1	2.4	4.0
CUM	150.	6.2	4.6	1.5	34.0	76.9	40.5	16.8	208.6	3.8	1.7	0.9	9.2

ALL IDLE SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	5.	5.8	2.4	3.9	9.7	65.5	33.6	20.1	99.8	3.3	1.3	1.8	5.2
CHRY	3.	8.7	1.8	6.9	10.4	143.4	12.6	133.5	157.5	4.0	0.2	3.8	4.1
DODG	8.	4.3	2.2	2.8	9.7	74.4	50.8	40.0	194.2	4.0	1.5	1.4	5.8
PLYM	9.	5.4	2.0	3.0	9.4	79.2	40.0	20.8	151.4	4.1	1.3	2.2	5.9
FORD	31.	5.3	2.2	2.7	10.9	74.8	44.9	19.5	208.6	4.0	1.9	0.9	7.9
MERC	7.	6.1	3.5	3.1	13.4	82.3	37.3	22.0	119.9	3.3	2.0	1.0	6.1
BUIC	10.	5.5	2.1	2.6	9.6	88.5	46.0	16.8	167.7	4.0	1.6	1.7	6.4
CADI	4.	4.1	2.1	1.6	6.3	83.8	61.1	23.4	146.2	4.4	2.5	1.8	7.7
CHEV	33.	8.4	6.1	2.7	34.0	83.6	33.0	16.9	145.8	3.9	1.6	1.0	7.2
OLDS	10.	8.2	7.5	3.4	27.4	84.4	25.9	48.5	136.1	3.5	1.2	2.1	5.6
PONT	12.	7.6	7.2	3.5	29.7	76.9	48.4	21.9	155.9	4.7	2.4	1.1	9.2
IMPT	6.	3.4	1.5	1.5	5.7	37.5	15.8	21.5	63.8	3.4	1.1	2.2	4.6
VW	12.	4.0	1.6	1.9	6.9	49.8	21.8	20.0	82.1	2.5	1.0	1.0	4.3
CUM	150.	6.2	4.6	1.5	34.0	76.9	40.5	16.8	208.6	3.8	1.7	0.9	9.2

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	3.	4.8	1.2	3.7	6.0	58.9	10.6	46.7	65.7	3.6	0.5	3.1	4.2
C.O.	77.	8.1	5.4	2.1	34.0	98.3	37.8	32.0	208.6	3.0	1.4	0.9	6.8
A.I.	9.	5.7	4.8	1.5	17.1	75.5	47.3	23.4	149.9	4.3	1.7	2.1	7.7
E.M.	61.	4.1	1.5	1.9	10.4	60.9	25.8	16.8	157.5	4.8	1.6	1.4	9.2
CUM	150.	6.2	4.6	1.5	34.0	76.9	40.5	16.8	208.6	3.8	1.7	0.9	9.2

```
                ALL IDLE SECOND SERVICE          1975 CVS TEST                 - PHASE 2 DATA

                                       ALL CARS

                                        100"  CLASS
 CID  NO.             HYDROCARBON                     CARBON MONOXIDE                  NITROGEN OXIDES
100" CARS      MEAN   SDEV    MIN     MAX      MEAN    SDEV    MIN    MAX       MEAN    SDEV    MIN     MAX
 X1   14.       3.8    1.6    1.9     6.9      46.1    22.2    20.0    82.1      2.7     1.1     1.0     4.3
 X2   21.       4.7    1.8    1.5     9.1      68.1    31.7    19.5   143.2      3.1     1.4     1.0     6.2
 X3   30.       8.4    6.4    2.8    34.0      82.6    37.7    20.1   177.9      3.6     1.6     0.9     6.8
 X4   70.       5.5    4.6    2.6    29.7      81.8    43.4    16.8   208.6      4.2     1.7     1.1     9.2
 X5   15.       5.0    2.0    1.6     9.6      83.4    45.0    21.9   167.7      4.5     1.8     1.8     7.7
CUM  150.       6.2    4.6    1.5    34.0      76.9    40.5    16.8   208.6      3.8     1.7     0.9     9.2

                                        1K#  CLASS
 WT   NO.             HYDROCARBON                     CARBON MONOXIDE                  NITROGEN OXIDES
 1K# CARS      MEAN   SDEV    MIN     MAX      MEAN    SDEV    MIN    MAX       MEAN    SDEV    MIN     MAX
 X2    0.       0.0    0.0 9999.0-9999.0        0.0     0.0 9999.0-9999.0      0.0     0.0 9999.0-9999.0
 X3   23.       4.1    1.7    1.5     8.0      53.4    26.4    19.5   119.9      3.0     1.3     1.0     6.2
 X4   44.       6.5    3.2    2.8    17.1      80.9    38.1    20.1   177.9      3.4     1.5     0.9     7.8
 X5   73.       7.0    5.8    2.6    34.0      82.9    42.9    16.8   208.6      4.3     1.7     1.0     9.2
 X6    5.       4.5    2.0    1.6     6.3      84.6    52.9    23.4   146.2      4.7     2.3     1.8     7.7
CUM  150.       6.2    4.6    1.5    34.0      76.9    40.5    16.8   208.6      3.8     1.7     0.9     9.2
```

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	14.	7.0	4.6	3.4	22.0	106.9	68.6	38.6	289.7	2.6	1.7	0.3	6.4
62-5	42.	13.0	15.9	3.6	79.4	119.2	66.7	28.1	387.1	3.0	1.4	0.4	5.8
66-7	30.	6.5	3.3	2.1	14.9	95.2	35.7	40.5	177.5	3.4	1.7	0.6	8.4
68-9	37.	5.7	5.6	2.2	35.7	74.9	44.3	9.1	229.9	4.1	1.7	0.8	8.8
70-1	27.	4.4	2.3	1.7	11.9	56.6	31.8	5.6	117.5	4.2	1.4	2.2	7.8
CUM	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	3.	3.8	1.1	2.8	5.0	56.4	51.4	25.1	115.8	4.8	1.4	3.8	6.4
X2	7.	4.3	2.5	2.1	9.2	64.1	37.4	18.2	117.5	2.8	0.8	1.2	3.5
X3	15.	5.7	3.1	2.4	13.8	84.0	53.9	25.7	220.4	4.4	1.7	0.9	7.8
X4	17.	5.4	3.0	2.5	12.5	69.1	52.5	5.6	229.9	3.9	1.3	1.8	6.9
X5	23.	5.2	2.7	1.7	14.9	80.9	36.3	9.1	177.5	3.5	1.6	1.0	7.6
X6	20.	7.5	4.7	2.2	22.0	102.3	64.2	13.7	289.7	3.4	2.2	0.3	8.8
X7	17.	9.3	7.7	2.1	35.7	107.8	59.8	37.8	291.7	3.3	1.9	0.4	8.4
X8	20.	9.2	16.8	2.8	79.4	86.2	37.7	35.2	189.6	3.6	1.5	1.6	6.4
X9	13.	14.5	17.9	3.6	60.1	123.6	88.4	53.0	387.1	2.7	1.4	0.4	5.0
X10	3.	12.0	15.1	5.0	48.8	104.7	57.2	51.5	216.5	3.1	1.2	0.9	4.4
X11	6.	7.7	4.0	3.4	15.0	101.6	34.7	49.6	144.3	2.9	1.4	0.8	4.1
X12	1.	7.7	0.0	7.7	7.7	87.9	0.0	87.9	87.9	3.7	0.0	3.7	3.7
CUM	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBUN				CARBON MONOXIDE				NITROGEN OXIDES			
		MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
AMC	5.	6.1	3.0	4.0	11.0	107.4	56.5	57.2	196.1	2.6	1.6	0.8	4.1
CHRY	3.	7.9	5.3	3.8	13.8	120.5	89.6	47.3	220.4	4.1	2.4	2.5	6.9
DODG	8.	5.0	2.6	2.7	10.5	70.2	44.4	13.7	153.3	4.7	1.6	2.4	6.5
PLYM	9.	7.2	4.1	3.4	14.9	128.2	72.2	49.5	291.7	3.6	2.2	0.4	7.6
FORD	31.	5.0	2.1	2.4	9.5	74.0	39.1	9.1	173.0	3.7	1.7	1.0	8.8
MERC	7.	16.3	27.9	3.6	79.4	96.5	51.3	37.8	189.6	3.1	1.6	1.2	4.9
BUIC	10.	7.7	3.4	3.3	12.5	135.1	42.5	91.4	229.9	2.8	1.0	0.9	4.5
CADI	4.	4.5	1.6	2.8	6.5	68.1	15.5	50.5	84.9	5.6	1.0	4.2	6.5
CHEV	33.	8.3	10.2	3.0	60.1	84.2	54.2	16.1	289.7	3.6	1.4	0.3	6.4
OLDS	10.	10.0	13.7	2.1	48.8	105.2	34.7	40.5	158.3	3.6	1.4	0.9	5.6
PONT	12.	11.5	11.7	3.5	45.8	119.3	90.3	29.2	387.1	3.9	2.2	0.4	8.4
IMPT	6.	11.5	12.9	2.1	35.7	62.8	58.8	5.6	169.3	2.6	1.1	0.6	3.6
VW	12.	5.2	3.5	1.7	15.0	67.7	24.6	22.8	115.0	2.2	0.8	0.8	3.9
CUM	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
		MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
N.C.	6.	5.7	2.2	3.8	9.8	77.3	32.9	38.6	118.6	3.6	1.8	1.8	6.4
C.D.	71.	10.7	12.8	3.4	79.4	115.2	60.3	28.1	387.1	3.0	1.6	0.3	8.4
A.I.	9.	7.4	10.7	2.1	35.7	68.8	22.0	40.5	108.1	3.7	1.6	2.1	5.9
E.M.	64.	4.8	2.6	1.7	14.9	68.6	42.5	5.6	229.9	4.1	1.6	0.8	8.8
CUM	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

ALL K.M. BEFORE SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
100"	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	14.	5.5	3.8	1.7	15.0	59.7	30.5	5.6	115.0	2.3	0.8	0.8	3.9
X2	20.	7.2	7.3	2.2	35.7	81.7	39.7	29.4	169.3	3.0	1.6	0.6	7.8
X3	29.	8.2	14.0	2.5	79.4	80.7	48.5	13.7	216.5	3.5	1.5	0.9	6.5
X4	72.	7.8	8.7	2.1	60.1	99.0	62.2	9.1	387.1	3.8	1.8	0.3	8.8
X5	15.	9.8	11.3	2.8	48.8	114.7	55.1	50.5	229.9	3.8	1.5	1.8	6.5
CU"	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

1K# CLASS

WT	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
1K#	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	28.	6.7	6.7	1.7	35.7	73.0	43.1	5.6	196.1	2.5	1.4	0.6	7.8
X4	47.	6.8	11.1	2.4	79.4	79.7	46.1	13.7	216.5	3.5	1.4	0.9	6.5
X5	70.	9.1	10.0	2.1	60.1	107.1	62.8	9.1	387.1	3.8	1.7	0.3	8.8
X6	5.	5.2	2.2	2.8	8.3	74.6	19.8	50.5	100.7	5.3	1.1	4.0	6.5
CUM	150.	7.8	9.7	1.7	79.4	91.0	55.4	5.6	387.1	3.5	1.7	0.3	8.8

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

YEAR CLASS

	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
YEAR	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
57-1	14.	5.8	2.0	3.2	10.3	79.9	37.9	34.2	173.0	3.1	1.7	1.0	6.4
62-5	42.	6.6	2.7	2.7	17.1	86.4	40.8	17.3	241.8	3.2	1.3	0.9	6.1
66-7	30.	5.5	2.1	2.1	11.1	74.6	23.2	36.9	125.2	3.6	1.6	1.2	8.4
68-9	37.	4.1	1.9	2.0	12.5	61.3	39.2	9.1	229.9	4.1	1.7	1.8	8.8
70-1	27.	3.7	1.3	1.7	8.5	50.8	31.7	8.8	117.5	4.0	1.3	2.1	6.7
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

10K CLASS

MILE	NO.	HYDROCARBON				CARBON MONOXIDE				NITROGEN OXIDES			
10K	CARS	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX	MEAN	SDEV	MIN	MAX
X1	3.	3.8	1.1	2.8	5.0	56.4	51.4	25.1	115.8	4.8	1.4	3.8	6.4
X2	7.	4.0	1.5	2.1	6.2	60.6	33.1	18.2	117.5	2.7	0.8	1.2	3.5
X3	15.	4.6	1.7	2.4	8.1	65.1	39.5	15.0	141.0	4.3	1.5	0.9	6.7
X4	17.	4.5	2.6	2.5	12.5	58.9	54.1	8.8	229.9	4.1	1.5	1.8	7.0
X5	23.	4.4	1.2	1.7	6.3	66.6	27.8	9.1	118.6	3.8	1.5	1.0	7.6
X6	20.	5.1	2.0	2.2	10.3	68.8	31.5	13.7	125.2	3.5	1.9	1.0	8.8
X7	17.	6.2	3.0	2.0	11.5	71.4	29.3	33.9	149.4	3.4	1.7	1.3	8.4
X8	20.	5.5	3.0	2.8	17.1	78.4	32.4	34.4	148.5	3.7	1.6	1.6	6.4
X9	13.	6.0	2.8	3.2	12.5	89.2	57.4	34.2	241.8	3.1	1.4	1.0	5.0
X10	8.	5.7	1.0	4.7	7.5	79.8	24.5	51.5	115.5	3.1	0.9	1.8	4.2
X11	6.	7.1	3.3	3.4	12.7	79.3	30.3	46.2	118.9	3.3	0.9	1.9	4.1
X12	1.	7.7	0.0	7.7	7.7	87.9	0.0	87.9	87.9	3.7	0.0	3.7	3.7
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

MAKE CLASS

VEH. MAKE	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
AMC	5.	4.5	1.0	3.2	5.9	76.7	26.9	56.1	122.2	2.8	1.4	1.0	4.1
CHRY	3.	6.0	2.3	3.6	9.1	91.7	43.4	47.3	133.9	4.3	2.2	3.0	6.9
DODG	3.	4.3	1.4	2.7	7.1	57.3	29.2	13.7	101.5	4.9	1.5	2.4	6.5
PLYM	9.	5.2	1.6	3.4	8.8	81.9	29.6	44.2	117.5	4.4	1.6	1.7	7.6
FORD	31.	4.6	1.8	2.4	9.5	63.3	36.4	9.1	173.0	3.7	1.6	1.0	8.8
MERC	7.	6.3	4.9	2.7	17.1	71.7	43.4	17.3	148.5	3.4	1.5	1.2	5.4
BUIC	10.	6.7	3.3	2.0	12.5	113.4	50.3	35.5	229.9	2.9	0.8	1.8	4.5
CALI	4.	4.5	1.6	2.8	6.5	68.1	15.5	50.5	84.9	5.6	1.0	4.2	6.5
CHEV	33.	5.3	1.9	3.0	11.1	61.1	23.5	16.1	101.9	3.9	1.4	1.3	7.0
OLDS	10.	5.6	1.9	2.1	8.0	97.8	30.8	40.5	141.0	3.2	1.3	0.9	5.6
PONT	12.	6.3	2.8	3.5	12.5	85.5	57.0	29.2	241.8	3.7	1.9	1.0	8.4
IMPT	6.	3.2	1.9	2.1	7.1	38.6	28.0	8.8	89.3	2.8	0.9	1.2	3.6
VW	12.	4.7	2.8	1.7	12.7	54.0	17.7	22.3	79.6	2.3	0.7	1.3	3.9
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

CTRL CLASS

EMIS CTRL	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
N.C.	6.	4.5	1.2	2.7	5.8	60.4	33.4	17.3	102.5	3.8	1.6	2.4	6.4
C.D.	71.	6.5	2.4	3.2	17.1	85.1	35.7	28.1	241.8	3.2	1.5	0.9	8.4
A.I.	9.	3.6	1.0	2.1	4.8	60.5	24.2	33.9	108.1	3.9	1.5	2.1	5.9
E.M.	64.	4.0	1.7	1.7	12.5	57.4	36.3	8.8	229.9	4.1	1.5	1.8	8.8
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

ALL K.M. SECOND SERVICE 1975 CVS TEST - PHASE 2 DATA

ALL CARS

100" CLASS

CID 100"	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X1	14.	4.3	2.7	1.7	12.7	48.2	22.0	8.8	79.6	2.4	0.7	1.3	3.9
X2	20.	4.4	1.6	2.2	7.1	61.7	32.0	17.3	122.2	3.2	1.5	1.0	6.7
X3	29.	5.4	2.9	2.5	17.1	61.3	26.3	13.7	148.5	3.9	1.4	1.3	6.5
X4	72.	5.2	2.0	2.0	12.5	75.1	38.4	9.1	241.8	3.9	1.6	0.9	8.8
X5	15.	6.5	2.7	2.8	12.5	101.8	48.5	38.2	229.9	3.7	1.6	1.8	6.5
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

1K# CLASS

WT 1K#	NO. CARS	HYDROCARBON MEAN	SDEV	MIN	MAX	CARBON MONOXIDE MEAN	SDEV	MIN	MAX	NITROGEN OXIDES MEAN	SDEV	MIN	MAX
X2	0.	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0	0.0	0.0	9999.0	-9999.0
X3	28.	4.2	2.2	1.7	12.7	53.7	27.7	8.8	118.8	2.6	1.2	1.0	6.7
X4	47.	4.7	2.2	2.4	17.1	53.1	31.8	13.7	148.5	3.7	1.3	0.9	5.5
X5	70.	5.9	2.4	2.0	12.5	82.6	41.8	9.1	241.8	3.9	1.6	1.0	8.8
X6	5.	5.2	2.2	2.8	8.3	74.6	19.8	50.5	100.7	5.3	1.1	4.0	6.5
CUM	150.	5.2	2.4	1.7	17.1	70.8	37.5	8.8	241.8	3.6	1.5	0.9	8.8

APPENDIX C

REGRESSION TABLES

C-1: 1975 CVS Data as Dependent Variable

C-2: 1972 CVS Data as Dependent Variable

```
             Z%      A       B1      B2       B3      B4      B5      B6       B7         AL%   BL%     F        SE     MR
EPA          1.   0.8550  1.1919  0.0      0.0     0.0     0.0     0.0      0.0         32.    3. 3984.857   2.169 0.9646
MH7MOD       1.   0.4085  0.9457  0.0      0.0     0.0     0.0     0.0      0.0         92.    4. 2143.221   2.874 0.9370
MKM STEP     0.   1.3321  1.2845  1.4652   0.2767  0.0     0.0     0.0      0.0          0.    0. 1384.453   2.128 0.9662
M-0MPH       4.   2.9653  2.7058  0.0      0.0     0.0     0.0     0.0      0.0         19.    7.  617.372   4.693 0.8212
M10MPH       8.   4.6669  1.5963  0.0      0.0     0.0     0.0     0.0      0.0         14.   10.  261.282   6.003 0.6835
M20MPH       2.   2.4199  3.2571  0.0      0.0     0.0     0.0     0.0      0.0         16.    4. 1628.045   3.235 0.9194
M30MPH       1.   1.9854  3.0171  0.0      0.0     0.0     0.0     0.0      0.0         18.    4. 1942.576   2.999 0.9311
M40MPH       2.   1.8731  2.6791  0.0      0.0     0.0     0.0     0.0      0.0         23.    5. 1316.205   3.534 0.9030
M50MPH       3.   2.1883  2.0753  0.0      0.0     0.0     0.0     0.0      0.0         24.    6.  781.929   4.320 0.8509
M60MPH       3.   1.9003  1.8799  0.0      0.0     0.0     0.0     0.0      0.0         27.    6.  852.491   4.186 0.8608
M-0MSTEP     0.   1.2455  1.0808 -0.0459   0.9336  0.2785  0.0466  0.9736   0.0          0.    0.  659.027   2.179 0.9649
VH7MOD       5.   2.3923  0.9340  0.0      0.0     0.0     0.0     0.0      0.0         27.    8.  441.787   5.220 0.7728
VKM STEP     0.   1.6976  0.0015  0.0179   0.0011  0.0     0.0     0.0      0.0          0.    0.  208.080   4.680 0.8236
V-0MPH      16.   4.7249  0.0050  0.0      0.0     0.0     0.0     0.0      0.0         17.   17.  100.732   7.110 0.5026
V10MPH       8.   3.0789  0.0105  0.0      0.0     0.0     0.0     0.0      0.0         24.   11.  251.834   6.055 0.6768
V20MPH       6.   2.5929  0.0142  0.0      0.0     0.0     0.0     0.0      0.0         25.    8.  420.960   5.295 0.7652
V30MPH       5.   2.2557  0.0166  0.0      0.0     0.0     0.0     0.0      0.0         27.    7.  523.741   4.953 0.7983
V40MPH       5.   2.3539  0.0189  0.0      0.0     0.0     0.0     0.0      0.0         25.    7.  544.102   4.893 0.8038
V50MPH       5.   2.9576  0.0194  0.0      0.0     0.0     0.0     0.0      0.0         20.    8.  473.033   5.113 0.7833
V60MPH       6.   3.8303  0.0187  0.0      0.0     0.0     0.0     0.0      0.0         16.    9.  363.542   5.520 0.7413
V-0MSTEP     0.   2.0707  0.0011 -0.0016   0.0044  0.0050  0.0104 -0.0036   0.0024      0.    0.   84.466   4.777 0.8182
72 CVS       0.  -0.4154  0.9647  0.0      0.0     0.0     0.0     0.0      0.0         26.    1.29981.746   0.816 0.9951

                              ALL CAL. BEFORE SERVICE   HC      REGRESSION SUMMARY TABLE
```

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	2.	26.5726	1.0568	0.0	0.0	0.0	0.0	0.0	0.0	14.	5.	1157.618	24.309	0.8918
MH7MOD	3.	23.0008	0.9552	0.0	0.0	0.0	0.0	0.0	0.0	19.	6.	842.385	27.465	0.8595
MKM STEP	0.	29.3447	1.3392	0.6025	0.5411	0.0	0.0	0.0	0.0	0.	0.	380.804	24.454	0.8912
M-0MPH	10.	37.6123	2.8319	0.0	0.0	0.0	0.0	0.0	0.0	17.	12.	213.928	40.992	0.6464
M10MPH	9.	37.5538	2.7237	0.0	0.0	0.0	0.0	0.0	0.0	16.	11.	252.517	39.529	0.6773
M20MPH	6.	37.9120	2.6570	0.0	0.0	0.0	0.0	0.0	0.0	13.	8.	432.556	34.314	0.7695
M30MPH	5.	42.4227	2.3862	0.0	0.0	0.0	0.0	0.0	0.0	10.	7.	553.886	31.777	0.8063
M40MPH	4.	46.0553	1.7765	0.0	0.0	0.0	0.0	0.0	0.0	8.	7.	626.538	30.503	0.8232
M50MPH	5.	48.6085	1.2590	0.0	0.0	0.0	0.0	0.0	0.0	8.	8.	506.062	32.708	0.7933
M60MPH	7.	52.7290	0.8530	0.0	0.0	0.0	0.0	0.0	0.0	8.	9.	350.440	36.422	0.7351
M-0MSTEP	0.	29.1147	0.9485	-0.1208	0.6663	0.3899	0.4019	0.1698	0.2900	0.	0.	163.146	24.492	0.8924
VH7MOD	3.	20.2859	1.1027	0.0	0.0	0.0	0.0	0.0	0.0	23.	6.	790.922	28.106	0.8523
VKM STEP	0.	28.8946	4.6394	7.5269	8.1215	0.0	0.0	0.0	0.0	0.	0.	148.435	34.064	0.7751
V-0MPH	14.	39.5000	5.5787	0.0	0.0	0.0	0.0	0.0	0.0	20.	16.	118.542	45.443	0.5335
V10MPH	13.	42.9713	9.6614	0.0	0.0	0.0	0.0	0.0	0.0	17.	15.	132.772	44.686	0.5552
V20MPH	10.	42.6438	12.0753	0.0	0.0	0.0	0.0	0.0	0.0	15.	12.	199.140	41.597	0.6329
V30MPH	17.	65.4974	6.3938	0.0	0.0	0.0	0.0	0.0	0.0	8.	18.	93.047	46.901	0.4878
V40MPH	7.	47.1607	17.0708	0.0	0.0	0.0	0.0	0.0	0.0	10.	9.	348.863	36.466	0.7344
V50MPH	8.	52.4144	15.5257	0.0	0.0	0.0	0.0	0.0	0.0	9.	11.	258.843	39.304	0.6818
V60MPH	9.	52.5765	14.6487	0.0	0.0	0.0	0.0	0.0	0.0	10.	11.	219.542	40.769	0.6513
V-0MSTEP	0.	32.3497	3.2989	-1.4188	3.9109	0.7542	6.8299	1.0427	5.7887	0.	0.	63.966	34.100	0.7780
72 CVS	0.	-2.9559	0.9150	0.0	0.0	0.0	0.0	0.0	0.0	74.	2.	5981.086	11.704	0.9760

ALL CAL. BEFORE SERVICE   CO   REGRESSION SUMMARY TABLE

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	4.	0.7265	0.9129	0.0	0.0	0.0	0.0	0.0	0.0	22.	6.	737.351	0.853	0.8439
MH7MOD	5.	0.6248	0.5577	0.0	0.0	0.0	0.0	0.0	0.0	32.	8.	479.088	0.985	0.7852
MKM STEP	0.	1.0720	-0.2113	0.2275	0.2119	0.0	0.0	0.0	0.0	0.	0.	121.084	1.069	0.7423
M-0MPH	68.	2.7852	3.7796	0.0	0.0	0.0	0.0	0.0	0.0	6.	61.	7.667	1.570	0.1584
M10MPH	56.	2.6680	3.8671	0.0	0.0	0.0	0.0	0.0	0.0	7.	50.	11.307	1.561	0.1912
M20MPH	32.	2.4296	2.7336	0.0	0.0	0.0	0.0	0.0	0.0	8.	30.	31.592	1.512	0.3096
M30MPH	12.	1.7697	1.7158	0.0	0.0	0.0	0.0	0.0	0.0	11.	14.	155.260	1.290	0.5853
M40MPH	7.	1.3537	0.8981	0.0	0.0	0.0	0.0	0.0	0.0	14.	10.	303.514	1.119	0.7103
M50MPH	6.	1.1596	0.4866	0.0	0.0	0.0	0.0	0.0	0.0	16.	9.	361.425	1.069	0.7403
M60MPH	7.	1.0406	0.3022	0.0	0.0	0.0	0.0	0.0	0.0	19.	9.	347.632	1.080	0.7338
M-0MSTEP	0.	0.9343	1.8325	-1.3197	0.8949	0.2777	0.1312	0.1418	0.1494	0.	0.	59.072	1.034	0.7656
VH7MOD	12.	1.5528	0.3492	0.0	0.0	0.0	0.0	0.0	0.0	15.	14.	148.368	1.299	0.5765
VKM STEP	0.	0.5871	-0.0004	0.0007	0.0006	0.0	0.0	0.0	0.0	0.	0.	85.007	1.170	0.6803
V-0MPH	301.	2.8447	0.0003	0.0	0.0	0.0	0.0	0.0	0.0	7.	262.	0.419	1.589	0.0375
V10MPH	714.	2.4758	0.0001	0.0	0.0	0.0	0.0	0.0	0.0	7.	621.	0.075	1.590	0.0158
V20MPH	63.	2.5484	0.0012	0.0	0.0	0.0	0.0	0.0	0.0	10.	57.	8.937	1.567	0.1706
V30MPH	17.	1.7599	0.0016	0.0	0.0	0.0	0.0	0.0	0.0	14.	17.	94.724	1.385	0.4911
V40MPH	14.	1.6733	0.0010	0.0	0.0	0.0	0.0	0.0	0.0	14.	15.	120.266	1.342	0.5362
V50MPH	10.	0.9128	0.0011	0.0	0.0	0.0	0.0	0.0	0.0	28.	12.	213.937	1.213	0.6464
V60MPH	11.	0.8280	0.0009	0.0	0.0	0.0	0.0	0.0	0.0	35.	13.	180.207	1.255	0.6139
V-0MSTEP	0.	0.8279	0.0001	0.0002	-0.0010	0.0006	0.0002	0.0005	0.0003	0.	0.	33.810	1.194	0.6691
72 CVS	0.	0.0907	0.9738	0.0	0.0	0.0	0.0	0.0	0.0	72.	2.	6999.742	0.321	0.9794

ALI CAL. BEFORE SERVICE NCX REGRESSION SUMMARY TABLE

```
              Z%     A       B1      B2       B3       B4       B5       B6       B7         AL%   BL%     F        SE    MR
EPA           1.   1.2955  1.0383  0.0      0.0      0.0      0.0      0.0      0.0         26.    4. 1992.386   2.513 0.9331
MH7MOD        2.   0.4747  0.8936  0.0      0.0      0.0      0.0      0.0      0.0         82.    4. 1636.107   2.735 0.9202
MKM STEP      0.   0.8616  1.5931  1.0274   0.4033   0.0      0.0      0.0      0.0          0.    0.  656.337   2.527 0.9328
M-0MPH        8.   2.5863  2.4093  0.0      0.0      0.0      0.0      0.0      0.0         27.   10.  269.536   5.055 0.6904
M10MPH        6.   2.4985  2.8650  0.0      0.0      0.0      0.0      0.0      0.0         24.    8.  409.917   4.525 0.7620
M20MPH        4.   2.6829  2.7126  0.0      0.0      0.0      0.0      0.0      0.0         19.    7.  609.395   3.995 0.8204
M30MPH        3.   2.8916  2.1915  0.0      0.0      0.0      0.0      0.0      0.0         15.    6.  876.987   3.510 0.8647
M40MPH        3.   2.3008  2.1259  0.0      0.0      0.0      0.0      0.0      0.0         18.    5. 1077.280   3.244 0.8857
M50MPH        4.   2.2859  1.7666  0.0      0.0      0.0      0.0      0.0      0.0         21.    6.  700.497   3.808 0.8384
M60MPH        5.   2.3073  1.5015  0.0      0.0      0.0      0.0      0.0      0.0         24.    8.  507.818   4.240 0.7948
M-0MSTEP      0.   1.3838  1.5222 -0.9415  -0.6568   1.3526   0.9234  -0.2233   0.4206       0.    0.  216.256   2.830 0.9161
VH7MOD        3.   2.4726  0.8586  0.0      0.0      0.0      0.0      0.0      0.0         16.    5. 1045.793   3.282 0.8828
VKM STEP      0.   2.7488  0.0042  0.0029   0.0049   0.0      0.0      0.0      0.0          0.    0.  326.251   3.370 0.8769
V-0MPH        6.   2.9411  0.0076  0.0      0.0      0.0      0.0      0.0      0.0         20.    9.  373.246   4.647 0.7468
V10MPH        5.   2.8856  0.0092  0.0      0.0      0.0      0.0      0.0      0.0         18.    7.  548.818   4.136 0.8060
V20MPH        4.   3.0687  0.0098  0.0      0.0      0.0      0.0      0.0      0.0         15.    7.  636.889   3.936 0.8263
V30MPH        4.   3.2729  0.0102  0.0      0.0      0.0      0.0      0.0      0.0         14.    7.  643.634   3.922 0.8276
V40MPH        4.   3.4276  0.0114  0.0      0.0      0.0      0.0      0.0      0.0         12.    6.  813.369   3.609 0.8563
V50MPH        3.   3.7006  0.0117  0.0      0.0      0.0      0.0      0.0      0.0         11.    6.  822.396   3.595 0.8575
V60MPH        3.   3.8210  0.0130  0.0      0.0      0.0      0.0      0.0      0.0         10.    6.  913.147   3.457 0.8690
V-0MSTEP      0.   2.9074  0.0032 -0.0018   0.0009   0.0032  -0.0017  -0.0017   0.0110       0.    0.  166.574   3.150 0.8949
72 CVS        0.  -0.3368  0.9276  0.0      0.0      0.0      0.0      0.0      0.0         49.    2.11117.074   1.125 0.9869

                                  ALL MI.  BEFORE SERVICE   HC      REGRESSION SUMMARY TABLE
```

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	3.	29.4849	0.9869	0.0	0.0	0.0	0.0	0.0	0.0	14.	6.	786.899	24.927	0.8524
MH7MOD	3.	24.1673	1.0210	0.0	0.0	0.0	0.0	0.0	0.0	18.	6.	803.259	24.741	0.8548
MKM STEP	0.	28.1980	1.3541	0.9677	0.3579	0.0	0.0	0.0	0.0	0.	0.	264.019	24.891	0.8540
M-0MPH	8.	37.0057	2.2142	0.0	0.0	0.0	0.0	0.0	0.0	16.	10.	263.802	34.670	0.6865
M10MPH	7.	38.4149	2.1543	0.0	0.0	0.0	0.0	0.0	0.0	14.	9.	346.546	32.361	0.7344
M20MPH	5.	41.4712	2.1498	0.0	0.0	0.0	0.0	0.0	0.0	11.	8.	460.563	29.823	0.7802
M30MPH	5.	48.9838	1.9749	0.0	0.0	0.0	0.0	0.0	0.0	8.	8.	445.388	30.126	0.7751
M40MPH	6.	54.4268	1.6241	0.0	0.0	0.0	0.0	0.0	0.0	7.	6.	416.845	30.723	0.7647
M50MPH	8.	53.9107	-1.3123	0.0	0.0	0.0	0.0	0.0	0.0	9.	11.	249.144	35.133	0.6760
M60MPH	13.	59.7825	0.8552	0.0	0.0	0.0	0.0	0.0	0.0	9.	14.	141.921	39.199	0.5693
M-0MSTEP	0.	30.2830	0.5627	0.3564	0.5299	0.2756	0.5399	0.0143	0.3186	0.	0.	132.151	23.533	0.8725
VH7MOD	4.	22.4287	-1.1282	0.0	0.0	0.0	0.0	0.0	0.0	23.	7.	557.802	28.073	0.8083
VKM STEP	0.	26.3032	5.4242	11.5953	5.6597	0.0	0.0	0.0	0.0	0.	0.	140.573	30.662	0.7676
V-0MPH	14.	37.3501	8.6881	0.0	0.0	0.0	0.0	0.0	0.0	21.	15.	127.169	39.876	0.5482
V10MPH	35.	71.7823	-2.4606	0.0	0.0	0.0	0.0	0.0	0.0	8.	33.	26.406	45.684	0.2862
V20MPH	8.	43.3835	11.8445	0.0	0.0	0.0	0.0	0.0	0.0	13.	11.	256.934	34.884	0.6817
V30MPH	8.	51.1698	14.7575	0.0	0.0	0.0	0.0	0.0	0.0	9.	10.	276.180	34.293	0.6948
V40MPH	7.	52.8759	19.3958	0.0	0.0	0.0	0.0	0.0	0.0	8.	10.	306.978	33.405	0.7135
V50MPH	10.	55.0596	19.5356	0.0	0.0	0.0	0.0	0.0	0.0	9.	12.	212.322	36.383	0.6463
V60MPH	14.	60.0641	17.9174	0.0	0.0	0.0	0.0	0.0	0.0	9.	15.	126.437	39.910	0.5471
V-0MSTEP	0.	28.2487	-3.2490	0.0	4.0868	1.2094	7.6936	7.4594	-1.2115	0.	0.	91.455	28.307	0.8084
72 CVS	1.	0.4609	0.8570	0.0	0.0	0.0	0.0	0.0	0.0	569.	3.	3773.417	12.859	0.9629

ALL MI. BEFORE SERVICE CC REGRESSION SUMMARY TABLE

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	5.	1.3678	0.8023	0.0	0.0	0.0	0.0	0.0	0.0	16.	7.	522.424	1.073	0.7990
MH7MOD	14.	2.5662	0.2915	0.0	0.0	0.0	0.0	0.0	0.0	10.	15.	125.262	1.495	0.5453
MKM STEP	0.	1.5028	-0.7510	0.4351	0.2051	0.0	0.0	0.0	0.0	0.	0.	131.721	1.169	0.7572
M-0MPH	92.	3.8771	4.2583	0.0	0.0	0.0	0.0	0.0	0.0	6.	81.	4.360	1.770	0.1205
M10MPH	185.	4.0638	-0.1484	0.0	0.0	0.0	0.0	0.0	0.0	5.	334.	0.259	1.783	0.0296
M20MPH	36.	3.3732	3.2162	0.0	0.0	0.0	0.0	0.0	0.0	8.	33.	26.114	1.710	0.2847
M30MPH	42.	3.6826	0.4137	0.0	0.0	0.0	0.0	0.0	0.0	6.	38.	19.564	1.727	0.2490
M40MPH	11.	2.2382	0.8277	0.0	0.0	0.0	0.0	0.0	0.0	12.	13.	176.422	1.412	0.6111
M50MPH	8.	1.5214	0.6282	0.0	0.0	0.0	0.0	0.0	0.0	19.	10.	271.464	1.288	0.6917
M60MPH	7.	1.2007	0.4218	0.0	0.0	0.0	0.0	0.0	0.0	25.	10.	298.619	1.258	0.7087
M-0MSTEP	0.	1.0381	3.4079	0.0480	0.1735	-0.0165	0.1422	0.1552	0.2825	0.	0.	47.229	1.232	0.7299
VH7MOD	5.	1.2022	0.7137	0.0	0.0	0.0	0.0	0.0	0.0	21.	8.	455.497	1.119	0.7785
VKM STEP	0.	0.6804	0.0014	0.0008	0.0007	0.0	0.0	0.0	0.0	0.	0.	131.559	1.169	0.7570
V-0MPH	65.	3.2293	0.0095	0.0	0.0	0.0	0.0	0.0	0.0	16.	58.	8.452	1.758	0.1666
V10MPH	152.	3.8622	0.0013	0.0	0.0	0.0	0.0	0.0	0.0	7.	133.	1.025	1.779	0.0739
V20MPH	52.	3.5795	0.0018	0.0	0.0	0.0	0.0	0.0	0.0	8.	47.	13.125	1.745	0.2061
V30MPH	20.	2.8925	0.0016	0.0	0.0	0.0	0.0	0.0	0.0	10.	20.	71.570	1.600	0.4413
V40MPH	12.	2.1046	0.0014	0.0	0.0	0.0	0.0	0.0	0.0	14.	14.	151.425	1.451	0.5818
V50MPH	11.	1.5308	0.0013	0.0	0.0	0.0	0.0	0.0	0.0	23.	13.	181.888	1.404	0.6169
V60MPH	10.	1.1421	0.0012	0.0	0.0	0.0	0.0	0.0	0.0	33.	12.	203.143	1.373	0.6380
V-0MSTEP	0.	0.9524	0.0043	-0.0003	-0.0004	0.0002	0.0004	0.0001	0.0009	0.	0.	30.845	1.364	0.6533
72 CVS	0.	0.2276	0.9799	0.0	0.0	0.0	0.0	0.0	0.0	38.	2.	6638.391	0.368	0.9784

ALL MI. BEFORE SERVICE NOX REGRESSION SUMMARY TABLE

```
            Z%    A       B1      B2      B3      B4      B5      B6      B7         AL%   BL%      F          SE    MR
EPA         1.    1.0422  1.1191  0.0     0.0     0.0     0.0     0.0     0.0        21.    2.  5395.629    2.403 0.9490
MH7MOD      1.    0.4170  0.9226  0.0     0.0     0.0     0.0     0.0     0.0        65.    3.  3780.439    2.812 0.9294
MKM STEP    0.    1.1424  1.4170  1.2188  0.3443  0.0     0.0     0.0     0.0         0.    0.  1877.784    2.357 0.9511
M-0MPH      4.    2.6687  2.5786  0.0     0.0     0.0     0.0     0.0     0.0        16.    6.   847.466    4.897 0.7662
M10MPH      6.    4.1915  1.8728  0.0     0.0     0.0     0.0     0.0     0.0        11.    7.   542.216    5.514 0.6902
M20MPH      2.    2.4957  3.0058  0.0     0.0     0.0     0.0     0.0     0.0        13.    4.  1946.248    3.690 0.8750
M30MPH      2.    2.4645  2.5671  0.0     0.0     0.0     0.0     0.0     0.0        12.    4.  2313.352    3.449 0.8917
M40MPH      2.    2.0897  2.3832  0.0     0.0     0.0     0.0     0.0     0.0        15.    4.  2234.492    3.497 0.8885
M50MPH      3.    2.2177  1.9189  0.0     0.0     0.0     0.0     0.0     0.0        16.    4.  1449.176    4.114 0.8418
M60MPH      3.    2.0707  1.6895  0.0     0.0     0.0     0.0     0.0     0.0        19.    5.  1292.930    4.280 0.8273
M-0MSTEP    0.    1.1557  1.0610  0.0265  0.2093  0.6176  0.4226  0.3790  0.2572      0.    0.   601.372    2.685 0.9365
VH7MOD      3.    2.4402  0.8939  0.0     0.0     0.0     0.0     0.0     0.0        16.    5.  1219.069    4.367 0.8195
VKM STEP    0.    2.7010  0.0018  0.0108  0.0018  0.0     0.0     0.0     0.0         0.    0.   383.246    4.455 0.8120
V-0MPH      8.    4.0103  0.0060  0.0     0.0     0.0     0.0     0.0     0.0        13.    9.   338.671    6.085 0.6019
V10MPH      5.    3.0206  0.0097  0.0     0.0     0.0     0.0     0.0     0.0        15.    7.   679.605    5.209 0.7299
V20MPH      4.    2.9867  0.0113  0.0     0.0     0.0     0.0     0.0     0.0        14.    6.   896.206    4.816 0.7750
V30MPH      4.    3.0516  0.0122  0.0     0.0     0.0     0.0     0.0     0.0        13.    6.   945.557    4.738 0.7832
V40MPH      3.    3.2046  0.0136  0.0     0.0     0.0     0.0     0.0     0.0        12.    5.  1047.596    4.589 0.7984
V50MPH      4.    3.6177  0.0139  0.0     0.0     0.0     0.0     0.0     0.0        11.    5.   969.231    4.702 0.7869
V60MPH      4.    3.9624  0.0147  0.0     0.0     0.0     0.0     0.0     0.0         9.    6.   930.970    4.761 0.7808
V-0MSTEP    0.    2.8519  0.0016 -0.0001  0.0015  0.0029  0.0036 -0.0026  0.0074      0.    0.   173.936    4.376 0.8207
72 CVS      0.   -0.3959  0.9485  0.0     0.0     0.0     0.0     0.0     0.0        25.    1.34190.066    0.997 0.9914

                              ALL CARS BEFORE SERVICE   HC      REGRESSION SUMMARY TABLF
```

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	2.	27.8139	1.0250	0.0	0.0	0.0	0.0	0.0	0.0	10.	4.	1932.866	24.626	0.8743
MH7MOD	2.	24.0515	0.9805	0.0	0.0	0.0	0.0	0.0	0.0	13.	4.	1629.323	26.252	0.8557
MKM STEP	0.	28.2446	1.4033	0.7368	0.4663	0.0	0.0	0.0	0.0	0.	0.	633.540	24.794	0.8729
M-OMPH	7.	39.0385	2.3833	0.0	0.0	0.0	0.0	0.0	0.0	11.	8.	435.743	38.554	0.6499
M10MPH	6.	39.0978	2.3715	0.0	0.0	0.0	0.0	0.0	0.0	10.	7.	552.301	36.545	0.6935
M20MPH	4.	40.0599	2.3615	0.0	0.0	0.0	0.0	0.0	0.0	8.	6.	857.638	32.480	0.7681
M30MPH	4.	45.6908	2.1747	0.0	0.0	0.0	0.0	0.0	0.0	6.	5.	985.297	31.142	0.7894
M40MPH	3.	50.2526	1.7034	0.0	0.0	0.0	0.0	0.0	0.0	5.	5.	1027.500	30.734	0.7955
M50MPH	5.	51.5716	1.2705	0.0	0.0	0.0	0.0	0.0	0.0	6.	6.	727.017	34.046	0.7413
M60MPH	6.	56.4639	0.8469	0.0	0.0	0.0	0.0	0.0	0.0	6.	8.	469.799	37.933	0.6639
M-OMSTEP	0.	29.5017	0.7494	0.1061	0.5919	0.3313	0.4612	0.1133	0.3110	0.	0.	298.141	23.935	0.8830
VH7MOD	3.	21.5273	1.1121	0.0	0.0	0.0	0.0	0.0	0.0	16.	5.	1346.227	28.100	0.8325
VKM STEP	0.	27.6412	5.2628	8.8230	6.8602	0.0	0.0	0.0	0.0	0.	0.	282.071	32.632	0.7665
V-OMPH	10.	39.0298	8.9689	0.0	0.0	0.0	0.0	0.0	0.0	14.	11.	240.121	42.827	0.5359
V10MPH	18.	64.3400	4.1569	0.0	0.0	0.0	0.0	0.0	0.0	7.	18.	93.438	47.163	0.3681
V20MPH	7.	42.9932	11.9389	0.0	0.0	0.0	0.0	0.0	0.0	10.	8.	447.660	38.333	0.6549
V30MPH	10.	63.0722	8.2782	0.0	0.0	0.0	0.0	0.0	0.0	6.	11.	244.710	42.710	0.5395
V40MPH	5.	50.7742	17.6654	0.0	0.0	0.0	0.0	0.0	0.0	6.	7.	632.900	35.326	0.7176
V50MPH	7.	54.9864	16.5235	0.0	0.0	0.0	0.0	0.0	0.0	6.	8.	451.752	38.258	0.6566
V60MPH	8.	56.9636	16.7930	0.0	0.0	0.0	0.0	0.0	0.0	6.	9.	336.686	40.549	0.6008
V-OMSTEP	0.	30.3757	3.1827	-0.1236	3.8759	0.0866	7.2670	2.3761	3.7547	0.	0.	135.119	31.599	0.7848
72 CVS	0.	-1.4310	0.8873	0.0	0.0	0.0	0.0	0.0	0.0	119.	2.	9345.379	12.420	0.9696

ALL CARS BEFORE SERVICE CO REGRESSION SUMMARY TABLE

```
              Z%      A        B1       B2       B3       B4       B5       B6       B7        AL%   BL%      F       SE     MR
EPA           3.   0.9690   0.8755   0.0      0.0      0.0      0.0      0.0      0.0       14.    5. 1356.928  0.984 0.9336
MH7MOD        7.   1.6491   0.3980   0.0      0.0      0.0      0.0      0.0      0.0       11.    8.  420.265  1.365 0.6431
MKM STEP      0.   1.2968  -0.5628   0.5243   0.1555   0.0      0.0      0.0      0.0        0.    0.  258.107  1.176 0.7523
M-OMPH       49.   3.3053   4.7358   0.0      0.0      0.0      0.0      0.0      0.0        4.   44.   15.149  1.760 0.1574
M10MPH      227.   3.4515   0.2439   0.0      0.0      0.0      0.0      0.0      0.0        4.  197.    0.741  1.781 0.0352
M20MPH       22.   2.8455   3.2830   0.0      0.0      0.0      0.0      0.0      0.0        6.   21.   64.981  1.692 0.3135
M30MPH       19.   2.8889   0.7567   0.0      0.0      0.0      0.0      0.0      0.0        5.   18.   90.624  1.660 0.3633
M40MPH        6.   1.6896   0.9125   0.0      0.0      0.0      0.0      0.0      0.0       10.    8.  492.838  1.324 0.6690
M50MPH        6.   1.3318   0.5633   0.0      0.0      0.0      0.0      0.0      0.0       13.    7.  569.965  1.274 0.6992
M60MPH        6.   1.1581   0.3587   0.0      0.0      0.0      0.0      0.0      0.0       16.    7.  564.706  1.277 0.6975
M-OMSTEP      0.   1.0221   2.0642   0.0336   0.6321   0.0348   0.3093   0.0807   0.2040     0.    0.   96.774  1.222 0.7311
VH7MOD        7.   1.5716   0.4845   0.0      0.0      0.0      0.0      0.0      0.0       12.    9.  387.766  1.387 0.6278
VKM STEP      0.   0.6963  -0.0005   0.0009   0.0006   0.0      0.0      0.0      0.0        0.    0.  220.399  1.228 0.7258
V-OMPH       62.   3.5665  -0.0007   0.0      0.0      0.0      0.0      0.0      0.0        5.  120.    2.009  1.779 0.0580
V10MPH       35.   3.5303  -0.0004   0.0      0.0      0.0      0.0      0.0      0.0        5.  203.    0.696  1.781 0.0342
V20MPH       57.   3.1604   0.0011   0.0      0.0      0.0      0.0      0.0      0.0        6.   50.   11.425  1.765 0.1371
V30MPH       14.   2.3115   0.0016   0.0      0.0      0.0      0.0      0.0      0.0        9.   14.  146.517  1.596 0.4442
V40MPH       10.   1.8672   0.0012   0.0      0.0      0.0      0.0      0.0      0.0       11.   11.  253.314  1.493 0.5461
V50MPH        8.   1.1576   0.0013   0.0      0.0      0.0      0.0      0.0      0.0       19.    9.  371.609  1.398 0.6197
V60MPH        7.   0.8933   0.0011   0.0      0.0      0.0      0.0      0.0      0.0       27.    9.  383.410  1.390 0.6257
V-OMSTEP      0.   1.0774  -0.0007  -0.0002  -0.0007   0.0005   0.0003   0.0003   0.0006     0.    0.   63.384  1.353 0.6552
72 CVS        0.   0.1158   0.9900   0.0      0.0      0.0      0.0      0.0      0.0       46.    1.14569.871  0.353 0.9802

                           ALL CARS BEFORE SERVICE   NCX     REGRESSION SUMMARY TABLE
```

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	1.	1.4417	1.2122	0.0	0.0	0.0	0.0	0.0	0.0	23.	3.	2822.756	2.622	0.9511
MH7MOD	2.	0.9825	0.9625	0.0	0.0	0.0	0.0	0.0	0.0	43.	4.	1753.428	3.233	0.9245
MKM STEP	0.	1.8855	1.2813	1.4585	0.3045	0.0	0.0	0.0	0.0	0.	0.	1056.493	3.488	0.9563
M-0MPH	4.	3.4824	2.7543	0.0	0.0	0.0	0.0	0.0	0.0	17.	7.	570.344	4.970	0.8104
M10MPH	9.	5.3363	1.6124	0.0	0.0	0.0	0.0	0.0	0.0	13.	11.	241.829	6.303	0.6693
M20MPH	2.	3.0404	3.3077	0.0	0.0	0.0	0.0	0.0	0.0	14.	5.	1351.419	3.606	0.9052
M30MPH	2.	2.5662	3.0830	0.0	0.0	0.0	0.0	0.0	0.0	15.	4.	1699.791	3.276	0.9224
M40MPH	2.	2.4400	2.7433	0.0	0.0	0.0	0.0	0.0	0.0	19.	5.	1218.747	3.760	0.89[illegible]4
M50MPH	3.	2.7365	2.1358	0.0	0.0	0.0	0.0	0.0	0.0	20.	6.	769.347	4.483	0.8490
M60MPH	3.	2.4238	1.9405	0.0	0.0	0.0	0.0	0.0	0.0	22.	6.	857.251	4.309	0.8614
M-OMSTEP	0.	1.7678	1.1327	-0.0631	0.7647	0.4781	-0.1082	0.9844	0.1046	0.	0.	445.913	2.507	0.9563
VH7MOD	6.	-3.0272	0.9457	0.0	0.0	0.0	0.0	0.0	0.0	23.	8.	403.802	5.528	0.7585
VKM STEP	0.	2.3616	0.0012	0.0183	0.0012	0.0	0.0	0.0	0.0	0.	0.	184.976	5.020	0.8076
V-0MPH	18.	5.4817	0.0049	0.0	0.0	0.0	0.0	0.0	0.0	16.	18.	86.971	7.464	0.4753
V10MPH	9.	3.8079	0.0105	0.0	0.0	0.0	0.0	0.0	0.0	21.	11.	218.919	6.441	0.6508
V20MPH	6.	3.2759	0.0142	0.0	0.0	0.0	0.0	0.0	0.0	21.	9.	369.000	5.670	0.7438
V30MPH	5.	2.8597	0.0171	0.0	0.0	0.0	0.0	0.0	0.0	22.	8.	488.757	5.221	0.7882
V40MPH	5.	2.9691	0.0192	0.0	0.0	0.0	0.0	0.0	0.0	21.	8.	501.713	5.179	0.7921
V50MPH	5.	3.5774	0.0198	0.0	0.0	0.0	0.0	0.0	0.0	18.	8.	441.735	5.385	0.7728
V60MPH	7.	4.4503	0.0191	0.0	0.0	0.0	0.0	0.0	0.0	15.	9.	349.281	5.756	0.7346
V-OMSTEP	0.	2.7530	0.0009	-0.0019	0.0038	0.0067	0.0103	-0.0051	0.0037	0.	0.	76.352	5.094	0.8042
75 CVS	0.	0.5044	1.0264	0.0	0.0	0.0	0.0	0.0	0.0	22.	1.	29981.746	0.842	0.9951

ALL CAL. BEFORE SERVICE HC REGRESSION SUMMARY TABLE

EPA	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
MH7MOD	4.	38.4301	1.0368	0.0	0.0	0.0	0.0	0.0	0.0	13.	7.	612.887	32.777	0.8203
MKM STEP	5.	34.3068	0.9495	0.0	0.0	0.0	0.0	0.0	0.0	16.	7.	530.294	34.372	0.8001
M-0MPH	0.	39.4297	1.4326	0.4690	0.5959	0.0	0.0	0.0	0.0	0.	0.	227.402	31.629	0.8351
M10MPH	11.	48.9265	2.7998	0.0	0.0	0.0	0.0	0.0	0.0	15.	13.	166.930	45.878	0.5992
M20MPH	10.	49.2214	2.6310	0.0	0.0	0.0	0.0	0.0	0.0	14.	12.	188.734	44.839	0.6227
M30MPH	8.	50.0827	2.5746	0.0	0.0	0.0	0.0	0.0	0.0	12.	10.	284.827	40.976	0.6991
M40MPH	7.	54.6496	2.3003	0.0	0.0	0.0	0.0	0.0	0.0	10.	9.	337.580	39.239	0.7288
M50MPH	6.	57.8168	1.7293	0.0	0.0	0.0	0.0	0.0	0.0	8.	9.	386.171	37.820	0.7513
M60MPH	7.	59.8563	1.2425	0.0	0.0	0.0	0.0	0.0	0.0	8.	9.	348.179	38.916	0.7340
M-0MSTEP	8.	63.6415	0.8501	0.0	0.0	0.0	0.0	0.0	0.0	8.	10.	266.217	41.646	0.6869
VH7MOD	0.	40.2648	0.9844	0.0	0.5590	0.2988	0.3156	0.2211	0.3138	0.	0.	101.138	32.978	0.8212
VKM STEP	5.	31.7729	1.0906	0.0	0.0	0.0	0.0	0.0	0.0	18.	8.	495.703	35.113	0.7903
V-0MPH	0.	42.4198	4.3081	6.5827	3.7755	0.0	0.0	0.0	0.0	0.	0.	92.488	41.309	0.6956
V10MPH	18.	53.4740	8.8612	0.0	0.0	0.0	0.0	0.0	0.0	17.	19.	81.175	50.802	0.4627
V20MPH	17.	55.9211	9.1568	0.0	0.0	0.0	0.0	0.0	0.0	14.	17.	95.068	49.896	0.4918
V30MPH	13.	55.3210	11.4515	0.0	0.0	0.0	0.0	0.0	0.0	13.	14.	139.789	47.279	0.5631
V40MPH	20.	77.1756	6.0525	0.0	0.0	0.0	0.0	0.0	0.0	8.	20.	68.734	51.657	0.4329
V50MPH	9.	59.4194	16.3565	0.0	0.0	0.0	0.0	0.0	0.0	9.	11.	229.644	43.066	0.6597
V60MPH	11.	64.1200	15.0528	0.0	0.0	0.0	0.0	0.0	0.0	9.	12.	195.840	44.973	0.6198
V-0MSTEP	12.	64.2972	16.1786	0.0	0.0	0.0	0.0	0.0	0.0	9.	13.	160.473	46.200	0.5916
75 CVS	0.	46.3126	2.3828	-0.9227	3.8807	0.6927	5.7974	1.8839	5.5935	0.	0.	39.473	41.496	0.6973
	0.	7.4668	1.0410	[illegible]	0.0	0.0	0.0	0.0	0.0	30.	2.	5981.086	12.484	0.9760

ALL CAL. BEFORE SERVICE   CO   REGRESSION SUMMARY TABLE

```
              Z%      A       B1       B2       B3       B4       B5       B6       B7        AL%    BL%       F       SE     MR
EPA           5.   0.8066   0.8729   0.0      0.0      0.0      0.0      0.0      0.0        22.     7.   538.503  0.955 0.8023
MH7MOD        6.   0.7135   0.5322   0.0      0.0      0.0      0.0      0.0      0.0        31.     9.   371.907  1.067 0.7451
MKM STEP      0.   1.1526  -0.1166   0.1391   0.2166   0.0      0.0      0.0      0.0         0.     0.    89.959  1.161 0.6906
M-0MPH       88.   2.7940   2.9873   0.0      0.0      0.0      0.0      0.0      0.0         6.    78.     4.689  1.587 0.1245
M10MPH       65.   2.6821   3.3796   0.0      0.0      0.0      0.0      0.0      0.0         7.    58.     8.459  1.577 0.1661
M20MPH       32.   2.4076   2.7737   0.0      0.0      0.0      0.0      0.0      0.0         9.    30.    32.219  1.519 0.3124
M30MPH       13.   1.8038   1.6411   0.0      0.0      0.0      0.0      0.0      0.0        11.    15.   133.760  1.329 0.5566
M40MPH        9.   1.4258   0.8474   0.0      0.0      0.0      0.0      0.0      0.0        14.    11.   238.113  1.192 0.6664
M50MPH        8.   1.2218   0.4647   0.0      0.0      0.0      0.0      0.0      0.0        16.    10.   291.142  1.138 0.7030
M60MPH        8.   1.1066   0.2890   0.0      0.0      0.0      0.0      0.0      0.0        19.    10.   282.776  1.146 0.6978
M-0MSTEP      0.   0.9455   1.2028  -1.7038   1.2322   0.2620   0.0290   0.1798   0.1425      0.     0.    47.364  1.106 0.7292
VH7MOD       14.   1.6205   0.3277   0.0      0.0      0.0      0.0      0.0      0.0        15.    15.   121.398  1.348 0.5380
VKM STEP      0.   0.7452  -0.0007   0.0006   0.0006   0.0      0.0      0.0      0.0         0.     0.    66.993  1.239 0.6359
V-0MPH      560.   2.8547   0.0002   0.0      0.0      0.0      0.0      0.0      0.0         7.   487.     0.121  1.599 0.0202
V10MPH     1355.   2.8718   0.0001   0.0      0.0      0.0      0.0      0.0      0.0         8.  1177.     0.021  1.599 0.0084
V20MPH       62.   2.5225   0.0012   0.0      0.0      0.0      0.0      0.0      0.0        10.    55.     9.401  1.575 0.1749
V30MPH       18.   1.7897   0.0015   0.0      0.0      0.0      0.0      0.0      0.0        14.    19.    84.067  1.413 0.4691
V40MPH       15.   1.7047   0.0009   0.0      0.0      0.0      0.0      0.0      0.0        14.    16.   106.396  1.373 0.5129
V50MPH       11.   0.9863   0.0011   0.0      0.0      0.0      0.0      0.0      0.0        27.    13.   180.432  1.262 0.6141
V60MPH       12.   0.9034   0.0009   0.0      0.0      0.0      0.0      0.0      0.0        33.    14.   154.017  1.299 0.5837
V-0MSTEP      0.   0.9093  -0.0001   0.0001  -0.0007   0.0005   0.0002   0.0005   0.0003      0.     0.    28.097  1.249 0.6344
75 CVS        0.   0.0285   0.9850   0.0      0.0      0.0      0.0      0.0      0.0       232.     2.  6999.746  0.323 0.9794

                                  ALL CAL. BEFORE SERVICE   NOX     REGRESSION SUMMARY TABLE
```

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	3.	2.1671	1.0472	0.0	0.0	0.0	0.0	0.0	0.0	21.	5.	1064.429	3.468	0.8845
MH7MOD	3.	1.3326	0.9022	0.0	0.0	0.0	0.0	0.0	0.0	39.	6.	950.255	3.623	0.8732
MKM STEP	0.	1.6262	1.5023	1.1039	0.4425	0.0	0.0	0.0	0.0	0.	0.	436.440	3.194	0.9037
M-0MPH	9.	3.4344	2.4481	0.0	0.0	0.0	0.0	0.0	0.0	22.	11.	227.654	5.589	0.6593
M10MPH	7.	3.3914	2.9070	0.0	0.0	0.0	0.0	0.0	0.0	20.	9.	319.903	5.154	0.7207
M20MPH	5.	3.6063	2.7117	0.0	0.0	0.0	0.0	0.0	0.0	16.	8.	433.455	4.736	0.7709
M30MPH	4.	3.7762	2.2107	0.0	0.0	0.0	0.0	0.0	0.0	14.	7.	606.730	4.257	0.8198
M40MPH	3.	3.0744	2.1908	0.0	0.0	0.0	0.0	0.0	0.0	16.	6.	825.060	3.820	0.8579
M50MPH	4.	3.0192	1.8349	0.0	0.0	0.0	0.0	0.0	0.0	18.	7.	600.930	4.271	0.8185
M60MPH	5.	3.0475	1.5576	0.0	0.0	0.0	0.0	0.0	0.0	20.	8.	445.219	4.698	0.7750
M-0MSTEP	0.	2.1438	1.6606	-1.0342	-0.9427	1.1803	1.2342	0.0	0.2746	0.	0.	175.096	3.492	0.9849
VH7MOD	4.	3.3178	0.8726	0.0	0.0	0.0	0.0	0.0	0.0	15.	6.	729.153	3.995	0.8434
VKM STEP	0.	3.4785	0.0039	0.0056	0.0025	0.0	0.0	0.0	0.0	0.	0.	257.473	3.917	0.8511
V-0MPH	7.	3.8397	0.0077	0.0	0.0	0.0	0.0	0.0	0.0	17.	10.	293.845	5.266	0.7058
V10MPH	6.	3.7576	0.0093	0.0	0.0	0.0	0.0	0.0	0.0	16.	8.	421.420	4.775	0.7664
V20MPH	5.	3.9466	0.0099	0.0	0.0	0.0	0.0	0.0	0.0	14.	8.	475.193	4.606	0.7850
V30MPH	5.	4.1453	0.0103	0.0	0.0	0.0	0.0	0.0	0.0	13.	8.	484.288	4.579	0.7878
V40MPH	4.	4.2588	0.0117	0.0	0.0	0.0	0.0	0.0	0.0	11.	7.	627.772	4.208	0.8244
V50MPH	4.	4.5078	0.0121	0.0	0.0	0.0	0.0	0.0	0.0	10.	7.	669.340	4.117	0.8327
V60MPH	4.	4.6276	0.0135	0.0	0.0	0.0	0.0	0.0	0.0	10.	6.	739.007	3.976	0.8450
V-0MSTEP	0.	3.8552	0.0022	-0.0012	0.0	0.0028	-0.0024	0.0	0.0114	0.	0.	169.211	3.791	0.8622
75 CVS	0.	0.5634	1.0500	0.0	0.0	0.0	0.0	0.0	0.0	30.	2.	11117.078	1.197	0.9869

ALL MI. BEFORE SERVICE HC REGRESSION SUMMARY TABLE

	Z%	A	B1	B2	B3	B4	B5	B6	B7	AL%	BL%	F	SE	MR
EPA	6.	43.9228	0.9682	0.0	0.0	0.0	0.0	0.0	0.0	13.	9.	367.584	35.780	0.7443
MH7MOD	6.	38.4060	1.0070	0.0	0.0	0.0	0.0	0.0	0.0	16.	9.	381.322	35.415	0.7503
MKM STEP	0.	42.5430	1.3247	0.9399	0.3673	0.0	0.0	0.0	0.0	0.	0.	123.700	35.739	0.7470
M-OMPH	11.	51.3211	2.1717	0.0	0.0	0.0	0.0	0.0	0.0	14.	13.	165.830	42.889	0.5992
M10MPH	10.	52.4713	2.1635	0.0	0.0	0.0	0.0	0.0	0.0	13.	12.	210.209	40.966	0.6444
M20MPH	8.	55.4236	2.1227	0.0	0.0	0.0	0.0	0.0	0.0	10.	10.	262.585	38.998	0.6856
M30MPH	8.	63.1263	1.9337	0.0	0.0	0.0	0.0	0.0	0.0	8.	11.	248.335	39.505	0.6754
M40MPH	9.	68.8739	1.5670	0.0	0.0	0.0	0.0	0.0	0.0	7.	11.	224.395	40.403	0.6567
M50MPH	12.	68.2000	1.2739	0.0	0.0	0.0	0.0	0.0	0.0	9.	14.	153.268	43.484	0.5841
M60MPH	15.	72.7948	0.8698	0.0	0.0	0.0	0.0	0.0	0.0	8.	16.	107.018	45.912	0.5153
M-OMSTEP	0.	43.7490	0.5232	0.3755	0.5645	0.3245	0.4228	-0.0831	0.4321	0.	0.	59.679	34.818	0.7656
VH7MOD	7.	36.8901	1.1090	0.0	0.0	0.0	0.0	0.0	0.0	19.	10.	296.030	37.880	0.7071
VKM STEP	0.	41.2223	5.2343	11.2576	5.8011	0.0	0.0	0.0	0.0	0.	0.	79.935	40.005	0.6679
V-OMPH	18.	52.4353	8.3756	0.0	0.0	0.0	0.0	0.0	0.0	18.	19.	84.082	47.276	0.4703
V10MPH	43.	85.7863	2.3396	0.0	0.0	0.0	0.0	0.0	0.0	8.	40.	19.441	51.977	0.2422
V20MPH	12.	57.4934	11.6417	0.0	0.0	0.0	0.0	0.0	0.0	12.	13.	163.311	43.006	0.5963
V30MPH	11.	65.3064	14.4320	0.0	0.0	0.0	0.0	0.0	0.0	9.	13.	170.614	42.668	0.6047
V40MPH	11.	67.4571	18.6641	0.0	0.0	0.0	0.0	0.0	0.0	8.	13.	176.391	42.407	0.6111
V50MPH	13.	69.5856	18.7800	0.0	0.0	0.0	0.0	0.0	0.0	9.	15.	130.359	44.637	0.5529
V60MPH	17.	73.9662	17.5514	0.0	0.0	0.0	0.0	0.0	0.0	8.	18.	87.164	47.086	0.4770
V-OMSTEP	0.	43.6620	2.2579	-0.0928	4.4924	1.4577	6.8439	5.6637	0.6793	0.	0.	39.131	38.813	0.6969
75 CVS	1.	6.5625	1.0820	0.0	0.0	0.0	0.0	0.0	0.0	44.	3.	3773.417	14.448	0.9629

ALL MI. BEFORF SERVICE CO REGRESSION SUMMARY TABLE

```
                Z%      A       B1      B2       B3       B4      B5      B6      B7        AL%   BL%      F        SE    MR
EPA             6.   1.4639  0.7588  0.0      0.0      0.0     0.0     0.0     0.0        18.    9.   396.789   1.164 0.7569
MH7MOD         14.   2.4522  0.2345  0.0      0.0      0.0     0.0     0.0     0.0        11.   16.   117.556   1.507 0.5332
MKM STEP        0.   1.5095 -0.7864  0.4525   0.1779   0.0     0.0     0.0     0.0         0.    0.   105.672   1.239 0.7203
M-0MPH        103.   3.7461  3.3085  0.0      0.0      0.0     0.0     0.0     0.0         6.   91.     3.498   1.770 0.1079
M10MPH        343.   3.9100 -0.1050  0.0      0.0      0.0     0.0     0.0     0.0         5.  471.     0.130   1.790 0.0209
M20MPH         40.   3.2988  2.9077  0.0      0.0      0.0     0.0     0.0     0.0         9.   37.    21.073   1.721 0.2578
M30MPH         46.   3.5645  0.3736  0.0      0.0      0.0     0.0     0.0     0.0         6.   42.    16.277   1.734 0.2282
M40MPH         13.   2.2258  0.7651  0.0      0.0      0.0     0.0     0.0     0.0        13.   14.   139.351   1.469 0.5658
M50MPH          9.   1.5374  0.5571  0.0      0.0      0.0     0.0     0.0     0.0        20.   12.   213.576   1.357 0.6474
M60MPH          9.   1.2191  0.3970  0.0      0.0      0.0     0.0     0.0     0.0        26.   11.   233.445   1.325 0.6679
M-0MSTEP        0.   1.0702  3.0712  0.0953   0.0903  -0.0175  0.1104  0.1417  0.2786      0.    0.    35.600   1.311 0.6849
VH7MOD          7.   1.2147  0.6731  0.0      0.0      0.0     0.0     0.0     0.0        22.    9.   343.650   1.207 0.7354
VKM STEP        0.   0.7375  0.0012  0.0008   0.0007   0.0     0.0     0.0     0.0         0.    0.   105.042   1.241 0.7193
V-0MPH         65.   3.0810  0.0055  0.0      0.0      0.0     0.0     0.0     0.0        16.   58.     8.459   1.756 0.1667
V10MPH        162.   3.7437  0.0012  0.0      0.0      0.0     0.0     0.0     0.0         8.  142.     1.428   1.776 0.0693
V20MPH         55.   3.4602  0.0017  0.0      0.0      0.0     0.0     0.0     0.0         8.   50.    11.481   1.747 0.1932
V30MPH         22.   2.8281  0.0015  0.0      0.0      0.0     0.0     0.0     0.0        10.   22.    59.642   1.625 0.4095
V40MPH         14.   2.1063  0.0013  0.0      0.0      0.0     0.0     0.0     0.0        15.   15.   120.181   1.502 0.5374
V50MPH         12.   1.5405  0.0012  0.0      0.0      0.0     0.0     0.0     0.0        23.   14.   149.171   1.452 0.5789
V60MPH         11.   1.1746  0.0011  0.0      0.0      0.0     0.0     0.0     0.0        33.   13.   165.596   1.426 0.5990
V-0MSTEP        0.   0.9310  0.0043 -0.0004  -0.0004   0.0002  0.0002  0.0001  0.0008      0.    0.    24.876   1.422 0.6125
75 CVS          0.  -0.0559  0.9770  0.0      0.0      0.0     0.0     0.0     0.0       161.    2.  6638.391   0.368 0.9784

                                     ALL MI.  BEFORE SERVICE   NOX     REGRESSION SUMMARY TABLE
```

```
            Z%     A       B1      B2       B3      B4      B5      B6      B7        AL%   BL%      F       SE    MR
EPA         1.   1.7653  1.1344  0.0      0.0     0.0     0.0     0.0     0.0        16.    3. 3302.018  3.114 0.9204
MH7MOD      2.   1.1260  0.9361  0.0      0.0     0.0     0.0     0.0     0.0        29.    3. 2607.792  3.435 0.9022
MKM STEP    0.   1.7909  1.3833  1.2890   0.3667  0.0     0.0     0.0     0.0         0.    0. 1337.063  2.865 0.9331
M-0MPH      4.   3.3929  2.6264  0.0      0.0     0.0     0.0     0.0     0.0        14.    6.  750.940  5.298 0.7467
M10MPH      6.   4.9629  1.8893  0.0      0.0     0.0     0.0     0.0     0.0        10.    8.  475.556  5.940 0.6662
M20MPH      3.   3.2579  3.0352  0.0      0.0     0.0     0.0     0.0     0.0        11.    4. 1471.668  4.256 0.8453
M30MPH      2.   3.1946  2.6094  0.0      0.0     0.0     0.0     0.0     0.0        11.    4. 1807.626  3.966 0.8672
M40MPH      2.   2.7554  2.4455  0.0      0.0     0.0     0.0     0.0     0.0        12.    4. 1923.699  3.874 0.8738
M50MPH      3.   2.8547  1.9848  0.0      0.0     0.0     0.0     0.0     0.0        14.    5. 1351.279  4.406 0.8330
M60MPH      3.   2.6970  1.7494  0.0      0.0     0.0     0.0     0.0     0.0        15.    5. 1219.808  4.563 0.8196
M-0MSTEP    0.   1.7523  1.1717  0.0123   0.0210  0.5204  0.5685  0.4038  0.2510      0.    0.  449.948  3.180 0.9177
VH7MOD      3.   3.1778  0.9072  0.0      0.0     0.0     0.0     0.0     0.0        13.    5. 1028.652  4.824 0.7957
VKM STEP    0.   3.4138  0.0015  0.0118   0.0015  0.0     0.0     0.0     0.0         0.    0.  345.087  4.817 0.7971
V-0MPH      9.   4.8455  0.0060  0.0      0.0     0.0     0.0     0.0     0.0        11.   10.  248.349  6.539 0.5710
V10MPH      6.   3.8125  0.0098  0.0      0.0     0.0     0.0     0.0     0.0        13.    7.  575.994  5.680 0.7010
V20MPH      4.   3.7579  0.0114  0.0      0.0     0.0     0.0     0.0     0.0        12.    6.  756.779  5.287 0.7479
V30MPH      4.   3.7896  0.0124  0.0      0.0     0.0     0.0     0.0     0.0        12.    6.  825.021  5.158 0.7620
V40MPH      4.   3.9233  0.0139  0.0      0.0     0.0     0.0     0.0     0.0        11.    6.  931.642  4.975 0.7809
V50MPH      4.   4.3240  0.0143  0.0      0.0     0.0     0.0     0.0     0.0         9.    6.  892.211  5.040 0.7743
V60MPH      4.   4.6696  0.0152  0.0      0.0     0.0     0.0     0.0     0.0         9.    6.  869.886  5.079 0.7703
V-0MSTEP    0.   3.6731  0.0014  0.0      0.0007  0.0030  0.0031 -0.0015  0.0080      0.    0.  175.532  4.795 0.8003
75 CVS      0.   0.5474  1.0362  0.0      0.0     0.0     0.0     0.0     0.0        18.    1.34190.090  1.043 0.9914

                           ALL CARS BEFORE SERVICE   HC      REGRESSION SUMMARY TABLE
```

```
             Z%     A        B1       B2       B3       B4       B5       B6       B7       AL%    BL%       F       SE     MR
EPA          4.  40.9140   1.0065   0.0      0.0      0.0      0.0      0.0      0.0       9.     5.   961.301  34.290 0.7857
MH7MOD       4.  36.8020   0.9696   0.0      0.0      0.0      0.0      0.0      0.0      11.     6.   893.734  35.059 0.7746
MKM STEP     0.  40.0482   1.4612   0.6363   0.5039   0.0      0.0      0.0      0.0       0.     0.   333.904  33.875 0.7923
M-0MPH       8.  51.4793   2.3654   0.0      0.0      0.0      0.0      0.0      0.0      10.    10.   318.688  44.743 0.5903
M10MPH       7.  51.6831   2.3459   0.0      0.0      0.0      0.0      0.0      0.0       9.     9.   387.707  43.144 0.6278
M20MPH       6.  52.9642   2.3176   0.0      0.0      0.0      0.0      0.0      0.0       8.     7.   541.267  40.126 0.6899
M30MPH       5.  58.8359   2.1140   0.0      0.0      0.0      0.0      0.0      0.0       6.     7.   579.803  39.463 0.7022
M40MPH       5.  63.3915   1.6494   0.0      0.0      0.0      0.0      0.0      0.0       6.     7.   588.940  39.311 0.7050
M50MPH       6.  64.3356   1.2439   0.0      0.0      0.0      0.0      0.0      0.0       6.     8.   470.472  41.436 0.6642
M60MPH       8.  68.5715   0.8471   0.0      0.0      0.0      0.0      0.0      0.0       6.     9.   349.005  44.019 0.6077
M-0MSTEP     0.  41.5290   0.7724   0.1720   0.5500   0.3318   0.3400   0.0936   0.3754    0.     0.   145.015  33.776 0.7953
VH7MOD       4.  34.4961   1.0965   0.0      0.0      0.0      0.0      0.0      0.0      13.     6.   772.109  36.584 0.7512
VKM STEP     0.  41.7041   5.0554   7.5986   7.2511   0.0      0.0      0.0      0.0       0.     0.   166.073  40.945 0.6754
V-0MPH      13.  53.2669   8.5323   0.0      0.0      0.0      0.0      0.0      0.0      12.    13.   165.828  49.026 0.4666
V10MPH      22.  77.2910   3.9663   0.0      0.0      0.0      0.0      0.0      0.0       7.    20.    68.703  52.486 0.3215
V20MPH       9.  56.3730  11.5575   0.0      0.0      0.0      0.0      0.0      0.0       9.    10.   302.476  45.144 0.5802
V30MPH      13.  76.0291   7.5216   0.0      0.0      0.0      0.0      0.0      0.0       5.    13.   171.277  48.852 0.4725
V40MPH       7.  64.2945  16.8850   0.0      0.0      0.0      0.0      0.0      0.0       6.     9.   387.660  43.145 0.6278
V50MPH       9.  69.1401  15.9022   0.0      0.0      0.0      0.0      0.0      0.0       6.    10.   299.504  45.219 0.5783
V60MPH      10.  69.9156  16.2447   0.0      0.0      0.0      0.0      0.0      0.0       6.    11.   235.135  46.938 0.5319
V-0MSTEP     0.  44.7936   2.7672  -0.1520   4.2573   0.6575   6.1244   2.5193   4.0592    0.     0.    76.499  40.335 0.6898
75 CVS       0.   7.1992   1.0595   0.0      0.0      0.0      0.0      0.0      0.0      25.     2.  9345.379  13.572 0.9696

                                     ALL CARS BEFORE SERVICE   CO      REGRESSION SUMMARY TABLE
```

```
              Z%      A       BI       B2       B3       B4       B5       B6       B7        AL%    BL%        F       SE     MR
EPA           4.   1.0297   0.8256   0.0      0.0      0.0      0.0      0.0      0.0        14.     5.  1016.449   1.073 0.7940
MH7MOD        8.   1.6422   0.3816   0.0      0.0      0.0      0.0      0.0      0.0        11.     9.   377.659   1.380 0.6228
MKM STEP      0.   1.3422  -0.5080   0.4710   0.1529   0.0      0.0      0.0      0.0         0.     0.   201.818   1.244 0.7105
M-0MPH       58.   3.2500   3.9779   0.0      0.0      0.0      0.0      0.0      0.0         4.    52.    10.827   1.748 0.1336
M10MPH      230.   3.3700   0.2384   0.0      0.0      0.0      0.0      0.0      0.0         4.   200.     0.723   1.763 0.0348
M20MPH       24.   2.7928   3.1295   0.0      0.0      0.0      0.0      0.0      0.0         6.    22.    59.767   1.682 0.3019
M30MPH       20.   2.8477   0.7039   0.0      0.0      0.0      0.0      0.0      0.0         5.    19.    78.599   1.658 0.3413
M40MPH        7.   1.7331   0.8483   0.0      0.0      0.0      0.0      0.0      0.0        10.     9.   388.459   1.373 0.6282
M50MPH        6.   1.3724   0.5311   0.0      0.0      0.0      0.0      0.0      0.0        13.     8.   474.503   1.316 0.6658
M60MPH        6.   1.1993   0.3396   0.0      0.0      0.0      0.0      0.0      0.0        16.     8.   477.757   1.314 0.6670
M-0MSTEP      0.   1.0698   1.3782   0.0582   0.7390   0.0296   0.2305   0.0962   0.1996      0.     0.    78.393   1.276 0.6942
VH7MOD        8.   1.6035   0.4555   0.0      0.0      0.0      0.0      0.0      0.0        12.     9.   328.654   1.416 0.5962
VKM STEP      0.   0.7960  -0.0007   0.0008   0.0006   0.0      0.0      0.0      0.0         0.     0.   178.801   1.281 0.6889
V-0MPH       60.   3.4825  -0.0007   0.0      0.0      0.0      0.0      0.0      0.0         5.   121.     1.959   1.761 0.0572
V10MPH       48.   3.4453  -0.0003   0.0      0.0      0.0      0.0      0.0      0.0         5.   214.     0.627   1.763 0.0324
V20MPH       56.   3.0763   0.0011   0.0      0.0      0.0      0.0      0.0      0.0         6.    49.    11.833   1.747 0.1395
V30MPH       15.   2.2959   0.0015   0.0      0.0      0.0      0.0      0.0      0.0         9.    15.   129.892   1.599 0.4230
V40MPH       11.   1.9013   0.0011   0.0      0.0      0.0      0.0      0.0      0.0        11.    11.   218.764   1.509 0.5182
V50MPH        8.   1.2064   0.0012   0.0      0.0      0.0      0.0      0.0      0.0        19.     9.   319.238   1.424 0.5906
V60MPH        8.   0.9597   0.0011   0.0      0.0      0.0      0.0      0.0      0.0        26.     9.   327.690   1.417 0.5956
V-0MSTEP      0.   1.1258  -0.0007  -0.0002  -0.0005   0.0004   0.0002   0.0003   0.0006      0.     0.    53.359   1.387 0.6226
75 CVS        0.   0.0209   0.9704   0.0      0.0      0.0      0.0      0.0      0.0       255.     1.14569.871   0.350 0.9802

                              ALL CARS BEFORE SERVICE   NOX     REGRESSION SUMMARY TABLE
```